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Issued July 27, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS—BULLETIN 200.

A. C. TRUE, Director.

COURSE IN CEREAL FOODS AND THEIR PREPARATION,

FOR

MOVABLE SCHOOLS OF AGRICULTURE.

BY

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WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1908.

THE OFFICE OF EXPERIMENT STATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., March 16, 1908.

Sir: I have the honor to submit and to recommend for publication as Bulletin 200 of this Office a Course in Cereal Foods and Their Preparation, for use in movable schools of agriculture, prepared by Miss Margaret J. Mitchell of the Drexel Institute of Art, Science, and Industry, Philadelphia, Pa., under the supervision of C. F. Langworthy, expert in food and nutrition of this Office. The intent of the projected series of courses of which this is the third is to provide more extended and specific instruction in agriculture and household economy than is now being given outside of regularly organized schools. The value of such instruction and the practicability of imparting it in the manner proposed has been clearly demonstrated in foreign countries.

In this bulletin an attempt has been made to reduce the subject of cereal foods to pedagogical form, and it is therefore hoped that the course submitted will aid in extending knowledge of the principles that underlie the science of nutrition as related to the proper selection and preparation of cereal foods for human consumption.

Respectfully,

A. C. True, *Director.*

Hon. James Wilson,
Secretary of Agriculture.

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PREFATORY NOTE.

This Course in Cereal Foods and Their Preparation, by Miss Margaret J. Mitchell, of the Drexel Institute of Art, Science, and Industry, Philadelphia, Pa., is the third of a series which is being issued by the Office of Experiment Stations upon various agricultural and domestic science subjects for use by farmers' institute workers in giving instruction in movable schools of agriculture.

The course as outlined consists of fifteen lectures, accompanied by an equal number of practice exercises, and a list of publications intended to be consulted by the students in looking up the references indicated in the several lectures. There is likewise a list of apparatus and material needed in giving instruction together with the price of each item. Each lecture is intended to occupy about one hour in its delivery. The students are not expected to take notes, but at the close of the lecture a syllabus embracing the points considered, and containing references to authorities which the student is expected to consult before the practice exercise is taken up, will be handed to each member of the class.

The movable school plan consists in the formation of classes of not less than eight nor more than fifteen persons who are over 18 years of age, and who are interested in the subject of which the course treats. The teaching force should consist of one, or at most of two, instructors who are experts in the subject which they present. Through this instrumentality it is believed that it will be possible to educate in one or more specialties ten or twelve persons in each community who will be well fitted for conducting special lines of work and eventually become experts and sources of information and aid to others. The introduction of courses of this character is intended to supplement the present method of institute work, and will, it is believed, round out the system of institute instruction, provide for its logical expansion, and furnish employment to skilled teachers throughout the entire year.

John Hamilton,
Farmers' Institute Specialist.

COURSE IN CEREAL FOODS FOR MOVABLE SCHOOLS OF AGRICULTURE.

GENERAL SUGGESTIONS TO TEACHERS.

The attempt has been made in the lectures outlined in this bulletin to cover the subject in as complete a manner as possible. As a consequence the teacher will probably find that in no case can the lectures be used in their entirety, but must be adapted both in amount and in character of instruction to the varying needs and capacities of different classes. It is especially important that no more of the preliminary scientific explanations and definitions shall be undertaken than the students are able to comprehend thoroughly or may be considered absolutely necessary to an understanding of the more practical operations which are discussed in later lectures.

Try to impress principles and not be content with the mere presentation of facts. In asking review questions be careful not to ask too many that can be answered by a mere repetition of facts learned, but ask those which can be answered only if the student has really understood and assimilated the knowledge. When possible, get the students to name other facts that illustrate the principles taught. Encourage the pupils to try other experiments than those suggested, if questions arise that might be answered by such experiments.

Each student should have a notebook and keep a full record of the experiments performed and the practice work done. This is an important part of the work, and the lecturer, by frequently examining the books, may be able to help the student to make the record clear and correct. Have all the work done by every student, as processes which the students have themselves carried out will be better remembered than those which have been merely observed.

The numbers in the text in parentheses refer to corresponding numbers in the list of books of reference in the Appendix. This list of books should be considered more or less elastic. Foods and the principles of nutrition are being studied to such an extent that in a short time there may be valuable data bearing on the subject that are not yet published. In order to keep abreast of the times the lecturer

will find, in addition to a constant use of libraries where they are within reach, that the Experiment Station Record will be of assistance with its monthly report of the work published by the various experiment station workers and other investigators. The reference list may be added to as new material appears which proves of value in such a course.

The exact quantity of food materials used as illustrative material in the lessons will depend upon the method of presenting the subject. In the list of materials and apparatus given in the Appendix the quantity estimated as a minimum required for a class of eight students is given. Where there are larger classes and each pupil performs much or all of the work the list will have to be modified.

SYLLABUS OF A COURSE OF LECTURES ON CEREAL FOODS AND THEIR PREPARATION.

FIRST LECTURE—THE COMPOSITION OF CEREAL AND OTHER VEGETABLE FOODS.

EXPLANATION OF TERMS.

Ordinary foods, such as cereal grains, meat, fish, eggs, potatoes, etc., consist of (1) refuse, such as bran of wheat, bones of meat and fish, shells of shellfish and eggs, skin of potatoes, etc.; and (2) edible portion, such as flour or meal, the flesh of meat and fish, whites and yolks of eggs, inside of the potato, etc. The edible portion consists of (*a*) water and (*b*) nutritious substances or nutrients. There are four classes of nutrients, each of which varies considerably in appearance, taste, and behavior. These are called protein, fats, carbohydrates, and mineral matters or ash. (References No. 23, p. 1; No. 21, pp. 72, 73; No. 24, p. 14.) The water and nutrients are sometimes called food principles.

CHEMICAL COMPOSITION OF THE NUTRIENTS.

The nutrients are unlike each other because they are (1) composed of different substances, just as bread and meat-loaf are different because composed of different substances, or (2) because the same substances are combined in different proportions, as, for example, cake and muffins are unlike, though containing the same ingredients. The materials of which the nutrients are composed are called chemical elements. (Reference No. 24, p. 5.)

Protein is composed of the elements carbon, hydrogen, oxygen, nitrogen, and sulphur. The fact that protein contains nitrogen gives it an importance as food, since nitrogen is an element essential to the body for formation, growth, and repair, and protein is the only food principle that will supply it.

Carbohydrates, including sugars and starches, are composed of the elements carbon, hydrogen, and oxygen. There are different kinds of sugar, such as cane sugar, milk sugar, etc., but all are composed of the same elements and have in general like properties. The starches, which are characteristic constituents of all cereals, include a wide variety, such as cornstarch, potato starch, wheat starch, etc., but all are composed of the same elements and chemically are closely related to the sugars.

Fats, including not only the fat of animals but also butter fat and the many oils found in vegetable foods, are also composed of carbon, hydrogen, and oxygen, but in a different proportion from that found in carbohydrates.

The mineral matters of food are composed of a number of different elements, among which are potassium, sodium, magnesium, calcium, phosphorus, sulphur, and iron. (Reference No. 24, p. 6.)

ANALYZING FOODS TO SHOW THEIR NUTRIENTS.

These different food principles can be separated from one another, some of them quite easily.

(1) *Water.*—Foods containing much water will appear wet and water can be squeezed out of them. Where only a little water is present it can be detected by heating the food so that the water will turn to steam or vapor and will pass out in that form. If foods are allowed to dry, the loss of weight will indicate that water was present and had evaporated.

(2) *Starch.*—If foods are grated or ground up and washed with cold water, starch, if present, will appear. It does not dissolve in water, so the grains will be floated out from the food. They are small enough to pass through thin muslin and can be separated by this means from the other coarser particles.

If starch be added to boiling water it will change in appearance. Instead of being an opaque, white powder it will become clear and the water will be thickened. This is one test for the presence of starch. If a drop of tincture of iodin be added to cooked starch it will be turned a deep blue color. This will not take place under ordinary circumstances unless starch is present, so that it also constitutes a test for starch.

(3) *Protein.*—Protein is a name applied to a group of compounds of which nitrogen is the most important constituent. White (albumin) of eggs, gluten of wheat, and lean meat are familiar examples of such compounds. All the bodies of the protein group are turned yellow by the addition of concentrated nitric acid, the color being intensified by boiling. Other tests show similar characteristics common to all the compounds of this group and they may be considered as belonging to one class of food principles.

The protein of wheat flour (gluten) will form a sticky, elastic mass if wet with water, and the other material can then be washed away from it so that it will be seen by itself. The protein of some other foods, such as eggs, peas, beans, etc., can be dissolved by water or chemicals and strained out, and then coagulated by heat, or rendered solid by adding some other chemical to the solution. Other experiments with protein compounds are given in Lecture 3, p. 23.

(4) *Sugar.*—The presence of sugar can be shown by a chemical test in which a change of color takes place if sugar or any food containing sugar is examined. (Lecture 3, Experiment 11 (A).)

(5) *Fats.*—Fat, when present in large quantities, can be melted out of food.

(6) *Mineral matter.*—Mineral matter can be shown by burning foods. The ash that remains is the mineral portion.

EXPERIMENT AND PRACTICE WORK, FIRST LECTURE.

Analysis of a Potato.

Materials needed.—For each student or for every two students one potato, one grater, a piece of cheese cloth 10 by 10 inches, a small saucepan, water, a 6-inch test tube, a label for the test tube, tincture of iodin, salt, sugar, and cornstarch.

Experiment 1.—Analyze a potato according to the directions in Reference No. 31, pp. 61, 62. Is there water in potatoes? What proved it? The residue left in the cheese cloth is called cellulose or crude fiber. Is it soluble? Dry and save some of the starch in a test tube marked " potato starch " to use in Experiment 14.

Analysis of Flour.

Experiment 2. (A) *Materials needed.*—One one-half pint beaker, one test tube, Bunsen burner or smokeless flame, copper gauze 6 by 6 inches, cotton for plugging the test tube, bread flour, unground wheat, cheese cloth 10 by 10 inches square, a knife, bowl of cold water, test tube and label, tincture of iodin, funnel, filter paper, vinegar, and concentrated nitric acid.

Exercise.—Fill a beaker half full of water. Put it on a piece of copper gauze over a Bunsen flame. The flame does not pass through the gauze, so there is little danger of breaking the glass. Fill a 6-inch test tube about one-third full of flour and cork it. Set this into the water and allow all to heat gradually until the water boils. Leave it in the water for five minutes, then take out the test tube, dry the outside, and notice the drops that have condensed on the inside of the tube. Does flour contain water?

(B) *Materials needed.*—Bread flour, small mixing bowl, small piece of cheese cloth, and large mixing bowl.

Exercise.—To about one-half cupful of bread flour add sufficient water to form a stiff dough and allow it to stand one-half hour. Place the dough in a piece of cheese cloth and work it gently with the fingers in a bowl of water. Continue this for several minutes and then hold the cloth and contents under a stream of running water. Continue working it until the water runs clear. Open the cloth and scrape together the contents. Work this a little in the fingers until it adheres together and becomes elastic. Stretch it like rubber, press it down over the end of a finger like a glove. This substance is called gluten. Is gluten soluble in water? Notice its color. Add a little dilute nitric acid to some familiar proteid, such as white of egg, and boil it in a test tube. Do the same with a little gluten. Is the color produced the same in both cases? Add nitric acid to a little starch and boil it. Have egg albumin and gluten properties in common? Of what food principle do you think gluten is an example? Chew some wheat until a gum-like mass is obtained. Has it the same properties as the gluten obtained from the flour?

(C) Allow the water in which the flour was washed to stand five minutes or more. Carefully pour away the water and save it to use in Exercise D. Examine the sediment. What color is it? Is it soluble in water? Add a little water to the sediment and stir over the fire until it boils. What change takes place in its appearance? Add a drop of iodin to a little of it. What do you think it must be? Dry a little of it and save it in a labeled test tube to use in Experiment 19.

(D) Filter the water in which the flour was first washed and heat the filtrate in a test tube. If albumin is present it will become coagulated with heat. Filter off any coagulated material and test it with nitric acid.

(E) Add to the filtrate left from Exercise D a little vinegar. Another precipitate will be formed. Filter it and test it with nitric acid as in Exercise B. What food principle is it?

Analysis of Peas or Beans.

Materials needed.—Dried peas, peanuts, or beans, mortar and pestle, wire strainer, filter paper, funnel, washing soda, vinegar, Bunsen burner, concentrated nitric acid, 6-inch test tubes, writing paper, a small piece of white china, and label for test tube.

Experiment 3.—(A) Powder some dried peas, peanuts, or beans in a mortar. Treat a little of the flour obtained as you treated wheat flour in Experiment 2 (A). Do dried peas and beans contain any water?

(B) Treat the ground peas or beans as directed in Reference No. 7, Experiment 69, pp. 142, 143. Use washing soda to make an alkaline solution and vinegar for the acid. The first straining may be

through cheese cloth and the liquid filtered through paper. Test with concentrated nitric acid the matter (vegetable casein) that became solid on adding vinegar. To what class of food principles does vegetable casein belong?

(C) Remove the residue left in the first filter paper and boil a little of it with water. Add a drop of iodin. What besides water and casein do peas and beans contain? Reserve the remainder of this residue and dry it for use in Experiment 14.

(D) Crush some peanuts on writing paper and warm if necessary. The grease spot shows what?

(E) Ash may be shown by burning some of the ground material on a piece of china over a Bunsen burner flame.

SECOND LECTURE—COMPOSITION OF THE BODY AND THE USES OF FOOD CONSTITUENTS IN THE BODY.

COMPOSITION OF THE BODY.

The elements that go to form the body are the same as those found in food, and they are combined so as to form the same substances. Water forms nearly two-thirds of the body weight, protein about one-fifth, fat varies with individuals, one-twentieth is mineral matter, and a minute portion is carbohydrate. (Reference No. 24, pp. 6, 7.) The lecturer will illustrate by blocks or charts showing the composition of the human body. All the tissues contain all five of these proximate principles, but in some tissues one or more principles will be found to a greater extent than in others. Thus, the blood contains a great deal of water, the muscles much protein and water, the bones a large amount of mineral matter, etc. The composition of the human body is so like that of other animals that a study of meat, including bone, flesh, and fat, will serve as an illustration of the human body.

THE USES OF FOOD.

We must eat food (1) to build body material, i. e., repair worn-out tissues and supply material for growth (Reference No. 23, p. 1), and (2) to furnish heat and energy, or, in other words, act as fuel. (Illustrate by explaining the generation of power or motion in an engine.) The only fuel that the body can use is food or body material formed from food. (Reference No. 24, pp. 8–10.)

Some parts of the foods are especially useful for building material. Mineral will be needed if bones are to be built, for bones are so largely composed of mineral. Protein will be needed if muscles are to be built, for muscles are so largely composed of protein. As only protein foods can build protein body tissues, and all the tissues contain protein, they are called tissue formers, or flesh formers. All the

foods that contain carbon and hydrogen (which are combustible) will act as fuel. Protein also serves as fuel, so it has a dual function in nutrition. (Reference No. 21, p. 73.)

HEAT OF COMBUSTION.

Foods differ as to the amount of heat they yield just as coal and wood do. Pure fat yields over twice as much heat as carbohydrates or protein, and in general fatty foods have a higher fuel value than proteid or carbohydrate foods. The amount of heat given by any food when burned is called its "heat of combustion." The unit used to measure the heat is called a "calorie." A calorie is the amount of heat required to raise 1 pound (pint) of water 4° F. (References No. 24, pp. 11, 12; No. 23, p. 2.)

NUTRIENTS FURNISHED BY VEGETABLE FOODS.

Most vegetable foods contain a smaller percentage of fat and protein than those of animal origin, though there are such exceptions as olives, nuts, etc., which contain a very large amount of fat, and beans or peas, which contain much protein. In general, it may be said that although we get a great deal of our protein and fat from vegetable foods, we depend on them almost exclusively for carbohydrate material, which in many cases forms nearly three-fourths of their entire weight. In animal foods the compounds more closely resemble the body compounds, and yet the body has the power of transforming vegetable protein into body protein and changing fat and carbohydrates to a form adapted to its use.

THE FITTING OF FOODS TO THE NEEDS OF THE BODY.

The amount of food needed to repair waste and provide for growth in children and also to supply energy and heat varies with (1) different individuals, (2) climate and clothing, more heat being lost by radiation in a cold climate or with little clothing, and (3) the amount of work done. If much work is done more fuel will be required than where the body expends but little energy. (Reference No. 36, pp. 369, 370.)

Other conditions, such as the age, health, and size of the individual, also enter into the question. By much careful study of a great number of people with a variety of occupations an average has been found which may act as a guide to the selection of the right kind and amount of food. This average is called a standard dietary. (Reference No. 23, pp. 6, 7.) According to such a standard women doing a moderate amount of work require 2,800 calories to be obtained from their daily food, while to renew the worn-out protein and keep the

body in normal condition the food provided should supply 0.224 pound of protein per day. The following table gives the amount of some common foods which would furnish 0.224 pound of protein and about 2,800 calories. (References No. 1, pp. 245–248; No. 19, pp. 383, 386.)

TABLE 1.—*Daily dietary for a woman doing moderate work, the food materials furnishing approximately a standard ration of 0.224 pound protein and 2,800 calories.*

Kind of food.	Amount.	Protein.	Heat of combustion.	Kind of food.	Amount.	Protein.	Heat of combustion.
	Ounces.	*Pound.*	*Calories.*		*Ounces.*	*Pound.*	*Calories.*
Beef chuck	6.00	0.064	448	Potatoes	8.50	0.008	128
Mackerel, salt	3.75	.032	184	Rice	1.60	.008	164
Two eggs	3.00	.024	108	Bread	8.00	.040	576
Butter	2.50	----------	565	Sugar	3.00	----------	348
Cheese	.80	.016	104				
Milk	13.00	.032	260	Total	----------	0.224	2,785

EXPERIMENT AND PRACTICE WORK, SECOND LECTURE.

A Study of Bone.

Experiment 4. Materials needed.—Dilute hydrochloric acid, two rib bones of mutton or lamb, a shin bone of beef sawed in two, 18 inches of copper wire No. 20, utensil in which the rib bone can be submerged in acid, a small piece of white china.

Exercise.—Follow the directions given in Reference No. 31, p. 157, using rib bones of mutton or lamb for B and C.

A Study of Fat.

Experiment 5. Materials needed.—One pound of beef suet, a saucepan, a strainer, a piece of cheese cloth 10 by 10 inches, nitric acid, test tube.

Exercise.—Examine a piece of suet. Is it a homogenous mass? Cut up some of it into small pieces, cover it with cold water, and allow it to boil until the water is boiled away. Then cook it slowly until the scraps are shriveled and settle to the bottom. Strain through a cheese cloth and let the clear liquid grow cold. This part is the fat. The remainder is membrane, which forms cells that hold the fat, which is liquid or semiliquid when the animal is alive. Test some of these scraps of membrane with nitric acid. What food principle do they contain?

A Study of Muscle.

Experiment 6. (A) *Materials needed.*—A meat press, a broiler, one-half pound of lean beef.

Exercise.—Warm a piece of meat slightly in a broiler near a fire and cut it into small pieces. Squeeze it in a meat press or iron lemon squeezer. What is one food principle found in muscle?

(B) *Materials needed.*—Filter paper and a funnel, 2 small saucepans, white of an egg, nitric acid, test tube.

Exercise.—Chop fine the squeezed meat left from Experiment A and add a little water to it. Stir it well and squeeze it again. Filter the liquid. Put the liquid obtained from Experiment A with this and boil it. Is it all liquid now? Test the coagulated material with nitric acid. What is this other food principle that you have found in the piece of muscle? (Lecture 1, p. 13.) Treat the solid part of meat that is left after squeezing with nitric acid. What food principle is found in the solid part of muscle?

(C) *Materials needed.*—A food chopper, 1 ounce of lean beef, a small piece of cheese cloth, a wire strainer, tincture of iodin.

Exercise.—Chop a small piece of meat fine. Put it in one-fourth of a cupful of water and stir it well. Strain it through cheese cloth. Is there any sediment in the liquid? Boil it and add a drop of iodin to a portion of it. Is starch found in muscles?

(D) Test for ash by burning a little meat on a piece of china.

What food principles have you found in vegetable foods? What in animal tissues? Make a list of each and compare them.

Balanced Menus.

Materials needed.—The foods given in the standard dietary (see second lecture, p. 18), dishes to put the foods on.

Exercise.—Weigh a balanced day's ration for a woman with moderate work. The one given in the second lecture will be a good one for the purpose. When the food is weighed and can be seen, have the students plan meals using for the three meals only the materials displayed. Set aside as much of these as will be planned for each meal. Have the students compare their customary diet with this dietary as to total amount and character to determine whether their home meals as provided are conspicuously lacking or in excess of any one of the food principles. Work out the cost of this dietary at local prices.

THIRD LECTURE—DIGESTION, ASSIMILATION, EXCRETION.

DIGESTION.

Digestion consists in large measure in rendering food soluble so that it may pass through the walls of the intestines and get into the blood and by this fluid be carried to all parts of the body. Food which is not thus digested passes from the body in solid form, having been of absolutely no nutritive value. It is only the foods which get into the blood and are carried to the tissues that can act as tissue formers or fuel, since the tissue building is done in that part of the

body in which the new tissues are needed. The act of forming muscle tissue takes place in the muscles, bone tissue in the bones, skin tissue in the skin, etc. The burning of the fuel foods takes place largely in the muscles.

In order that solid foods may be made liquid some solvent must act on them. Water will dissolve salt or sugar. Not all foods, however, are readily soluble in water alone, and therefore the body must provide some material which, when added to water, will dissolve the foods that enter the body in solid form. There is no one substance in the body which will dissolve every known solid food, consequently the body secretes several substances called digestive ferments, one of which will act on one kind of food and dissolve it, others of which will dissolve other foods. Thus a great variety of foods can be digested.

As will be remembered from the first lecture, all foods are composed of five classes of compounds, known as the five food principles. One organ or set of organs will secrete the necessary material to digest one of these, such as starch, another will secrete material for digesting the proteid parts of food, another organ will secrete that which will emulsify or alter fats, while still another will change the sugar.

The whole set of organs which is devoted to the liquefying of food is called the alimentary canal. The names of these organs are the mouth, esophagus or gullet, stomach, and intestines. Opening into the walls of these organs are smaller organs called glands, whose function is to secrete liquids, one gland secreting one kind of liquid and another gland another kind, which they pour into the alimentary canal to become mixed with the food. Some open into the mouth and secrete saliva, one, named the pancreas, opens into the intestine, the liquid that comes from it being called pancreatic juice. The liver also secretes a material called bile, which pours into the intestines and aids, indirectly, in the liquefying of foods. Besides these large glands there are, in the walls of the canal, hundreds of very small ones, each of which pours out its digestive fluid. Those in the walls of the stomach pour out what is called stomach or gastric juice, those in the walls of the intestines secrete intestinal juice. These many juices are each composed of water and some material which will aid the water in dissolving food. Among these materials are ferments (Reference No. 45, pp. 97–99), which attack foods, breaking them up chemically as yeast breaks up sugar in wine and bread making, so that the elements of which they are composed may be recombined in other compounds which are soluble.

Note.—The teacher will show by chart or blackboard drawing a diagram of the alimentary canal, indicating the enlargements where mouth and stomach occur, the salivary and pancreatic glands, the gall bladder, and liver.

Carbohydrates are digested by the saliva and intestinal juice. Proteids are digested by the stomach juice and the intestinal juice. Fats are digested chiefly by the intestinal juice. (Reference No. 31, p. 199.)

The chewing of food is an important feature of the digestive process. The walls of the alimentary canal are in constant motion when food is passing through, so that it is turned over and over, kneaded, and mixed with digestive juices, but large unchewed masses or particles of food surrounded by tough cell walls or coatings of impervious material will not digest so readily. Chewing is therefore of great assistance in breaking up the food and exposing as large a surface of it as possible to the action of the digestive juices.

ASSIMILATION.

When the food is made liquid, it will pass through the minute organs situated in the walls of the intestines and is emptied into small tubes which gradually unite to form larger and larger tubes and which bear it toward the heart. Before it is poured into the blood all the food, except the fat, must pass through the liver. This is in order that the liver may have an opportunity to still further change it, and to hold back that which is not needed at once in the other parts of the body. It will, from time to time, allow whatever food may be needed to pass out again and be carried up and poured into a large vein that leads into the heart. It then forms a part of the blood and is pumped by the heart, through the arteries, to every part of the body. When it reaches tissues that need repair these tissues take what material they need for this purpose from the blood. The waste material, that which comes from worn-out tissue, etc., is taken up by the blood and borne away. If energy be needed that work may be done, the muscles, which are adapted to the burning of fuel and use of power, use the stored material which forms part of their substance or take from the blood the fuel elements they need, also the oxygen for combustion or oxidation which the blood has acquired in the lungs from the air. The oxidation of foods in the body is essentially the same process as combustion or burning as we are familiar with it and results in the same waste products. (Reference No. 31, pp. 1–5.) The blood also carries away from the tissues these combustion products. The blood, then, is a kind of vehicle carrying to the tissues building material and fuel and bearing away waste matter. These processes that take place in the tissues are called metabolism.

EXCRETION.

As the blood vessels form an endless circuit, passing from the heart to the tissues, on through them and back again to the heart, the waste matter would be carried again to the heart and sent around

to the tissues once more. In time this would collect in large amounts and would act as poison to the tissues. There must be some arrangement made, therefore, by which these poisonous waste products can be removed from the blood. To accomplish this the blood passes through certain organs which have the power of extracting from it the waste material. The principal organs for this purpose are the lungs, sweat glands, kidneys, and liver. It will be seen that the liver has many kinds of work to do. The material thus taken up by the liver is emptied, by means of the bile, into the intestines and in this way passes out of the body along with the undigested solid food. The sweat glands secrete the waste they have received upon the surface of the skin, and the kidneys secrete their waste matter in the form of urine. (Reference No. 24, p. 22.) In the lungs the carbon dioxid is removed. Water, one of the principal excretory products, is removed in the excretion of the lungs, kidneys, intestine, and skin.

NOTE.—The teacher will illustrate by chart, blackboard drawing, or in other ways the circulation of the blood, the lacteals and lymphatics, and the excretory organs.

EXPERIMENT AND PRACTICE WORK, THIRD LECTURE.

A Study of the Organs of Digestion in a Fowl.

Experiment 7. Materials needed.—One fowl, a pair of strong scissors, sharp knife, a board to work on.

Exercise.—Dissect out the organs of digestion of a fowl. (Reference No. 31, pp. 195–198.) Notice the mucous membrane that lines the gizzard.

Illustrations of Digestive Processes.

Experiment 8. Materials needed.—Rock salt, common salt, rock candy, granulated sugar, warm water, 4 tumblers, 4 spoons.

Exercise.—(A) One student take a little rock salt in a tumbler and add to it a certain quantity of warm water. Stir it until it is dissolved. At the same time a second student take an equal weight of common salt and an equal amount of water at the same temperature and stir it until dissolved. Which dissolves first—the fine common salt or the coarse rock salt?

(B) Do the same thing with rock candy and granulated sugar.

From these experiments would you deduce that there was any advantage in chewing food finely instead of swallowing it in large pieces? Explain the reason.

Experiment 9. Materials needed.—One-half teaspoonful of precipitated chalk, warm water, vinegar, tumbler, 10 cubic centimeter measuring glass, fibrin, glycerin extract or a dry preparation of pepsin, 2 per cent solution of hydrochloric acid, 3 small saucepans, 3 test tubes and labels for them, 1 per cent solution of sodium car-

bonate (sal soda), glycerin extract of pancreas or a dry preparation of pancreatin, thermometer.

Exercise.—(A) Try to dissolve a little precipitated chalk in warm water in a tumbler. Add vinegar and observe that it readily dissolves.

(B) Put into a test tube a few shreds of fibrin (a proteid) and mark it "B;" add 5 cubic centimeters of warm water. Keep it at 40° C. in a saucepan of warm water for twenty minutes. Does the water dissolve the fibrin?

(C) Add to the fibrin in test tube B a few drops of glycerin extract of pepsin or a little powdered pepsin, and 10 cubic centimeters of 2 per cent solution of hydrochloric acid. Keep it at 40° C. for twenty minutes. Has the addition of the pepsin and acid aided the water in dissolving the fibrin?

The stomach juice or gastric juice is composed mainly of water, the two ferments pepsin and rennin and hydrochloric acid. The dissolving of fibrin in Exercise C illustrates or imitates the digestion of proteid foods in the stomach. The proteids when thus changed are called peptones.

(D) Put into another test tube a few shreds of fibrin and add 10 cubic centimeters of 1 per cent solution of sodium carbonate and a little glycerin extract of pancreas. Keep it at 40° C. for one hour in a saucepan of water. This solution illustrates the action of the pancreatic juice as it takes place in the intestines.

NOTE.—If preferred, egg albumin may be used instead of fibrin in Exercises B, C, and D of Experiment 9, according to the directions in Reference No. 47, p. 94. The egg albumin requires more time to digest than fibrin.

The mucous membrane of a chicken gizzard, when dried and pulverized, is said to possess digestive powers. This might be prepared and tested.

Experiment 10. Materials needed.—Cornstarch, filter paper, glass funnel, 4 test tubes and labels, 2 small saucepans, thermometer, 10 cubic centimeter measuring glass, tincture of iodin, small white porcelain plate, a slice of bread, a glass stirring rod.

Exercise.—(A) Boil about 1 gram of starch in about 100 cubic centimeters of water. Collect saliva in a test tube, dilute it with 2 volumes of water and filter it through wet filter paper into a test tube and label it. Place 3 volumes of the cooked starch in a test tube and add 1 volume of the filtered saliva. Keep it at about 40° C. in a saucepan of warm water.

Take out a few drops from time to time and put them on a white porcelain plate. Add a drop of tincture of iodin. Note the color at once, after five minutes, after ten minutes, and after fifteen minutes.

Is there any starch present at the end of fifteen minutes? Mark the test tube "A" and keep the contents for use in Experiment 11.

(B) Into a test tube marked "AA" put 1 or 2 boluses of bread the size of a pea, made by chewing a piece of bread slightly. Add 2 cubic centimeters of warm water and keep the test tube at about 40° C. in a saucepan of warm water.

Into another test tube marked "BB" put an equal quantity of the bread chewed fine, dilute with warm water as before, and keep it at the same temperature. Test each one occasionally with iodin. Which one digests first? Compare with Experiment 8.

(C) Perform Experiment 96 in Reference No. 48, p. 94.

Experiment 11. Materials needed.—Glucose, Fehling's solution (an alkaline solution of copper sulphate to which Rochelle salt has been added), 10 cubic centimeter measuring glass, 3 test tubes and labels, test-tube holder, contents of test tube B from Experiment 10, glass stirring rod, tumbler, glycerin extract of pepsin, or a dry pepsin preparation.

Exercise.—(A) Perform Experiment 93, Reference No. 48, p. 92.

(B) Put 1 cubic centimeter of Fehling's solution into a test tube and boil it. Add about 2 cubic centimeters of the starch and saliva (test tube A) from Experiment 10. Heat it again. What is indicated? To what substance is starch finally changed by the process of digestion?

(C) Perform Experiment 97, Reference No. 48, p. 96.

In what part of the body does the pancreatic juice act upon food? To what substance does pancreatic juice change starch? If, through lack of sufficient mastication, starch did not become thoroughly mixed with saliva, would it necessarily pass from the body undigested?

Experiment 12.—Perform Experiments A and B in paragraph 2, Reference No. 31.

FOURTH LECTURE—A STUDY OF STARCH.

STRUCTURE OF STARCH GRAINS.

Starch is found in large quantities in all cereals, most vegetables, and some fruits. If it is examined under the microscope, starch will be found to be made up of grains which have a more or less definite shape, starch grains from each different vegetable growth having their own characteristic form, so that among a mass of unknown grains the source of each can be told. (Reference No. 20, pls. 47–53, pp. 1193, 1194.) The ring markings, which can be seen clearly in the picture of barley starch (Reference No. 20, pl. 50), indicate that the starch grain is built up in layers and the whole is covered by a very thin elastic and somewhat porous layer or membrane. (Reference No. 42, pp. 221, 223, fig. 1; p. 224, fig. 11.)

CHEMICAL CHARACTERISTICS OF STARCH.

Starch is composed of the three elements carbon, hydrogen, and oxygen. These elements are always found in the same proportions in every kind of starch no matter how different in size and shape. To every 6 parts of carbon there are 10 of hydrogen and 5 of oxygen. For convenience this is expressed $C_6H_{10}O_5$. As the oxygen and hydrogen occur in the same proportion as in water (H_2O), starches and related bodies are called carbohydrates.

Several carbohydrates have been found to be constituents of starch (Reference No. 42, p. 220), but it consists chiefly of a substance called amylose. There are two kinds of amylose with somewhat different characteristics. One of these is readily acted upon by ferments and the other is insoluble in saliva, showing that the ferment ptyalin does not readily act upon it. The outer layer is of this character. Starch is ordinarily said to be insoluble in water, but careful tests show that a small percentage of the starch grain is soluble in cold water. Starch will give a blue color with iodin, and as this is the only common substance that gives this color reaction, it may be conveniently used as a test for the presence of starch.

CHANGES WHICH STARCH UNDERGOES DURING COOKING.

(A) *Physical changes.*—When boiling water is added to starch the outer covering is softened and the grains burst and the starch substance mingles with the water, forming a gelatinous mass which jellies when cold. It becomes nearly clear instead of opaque white, as raw starch is. If boiled a long time, part of the starch dissolves. These ruptured or dissolved grains are much more readily digested than raw starch, which to a greater or less extent escapes digestion because the digestive juices do not reach it on account of the unbroken cell walls. (References No. 43, p. 354; No. 9, pp. 383, 384, figs. 29, 31, 32.)

(B) *Chemical changes.*—If starch is heated to 320° F. it is changed chemically. (Reference No. 7, p. 148.) The new substance formed, called dextrin, is soluble in cold or hot water and will not give a blue color with iodin, but instead a brown. Dextrin is formed when starchy foods are baked thoroughly, as bread crust.

Heat is not the only means of changing starch to a soluble form. Some ferments like ptyalin, which is found in saliva, and a ferment called diastase, found in cereals, will also bring about such a change. When malt (which is sprouted barley grains dried and powdered and which contains a large amount of diastase) is added to flour or starch, the diastase transforms the starch to dextrose, glucose, or grape sugar. (See Experiment 11 (A) for test for dextrose.) Until the age when ptyalin is formed in the saliva of children starch is indigestible and

irritating. Hence many infant foods are made by treating starch with malt. Often, however, the process of inversion, as it is called, is incomplete and most of the starch is left unchanged. Heating with certain acids will also change starch to dextrose. This is the way in which commercial glucose is made from starch. The dextrose solution is afterwards purified from the acid (Reference No. 7, pp. 200, 201), and the solid grape sugar may be obtained also if desired.

FOOD VALUE OF STARCH.

As hydrogen and carbon are combustible materials and oxygen is the element needed to cause burning, it will be seen that starch is a fuel food. Although starch, like fat, does not enter into the formation of the body tissues, which it will be remembered contain nitrogen, it is found that when plenty of starchy foods is eaten the proteid tissues of the body are not used up as rapidly as if one were fasting, so that it, like fat, may be considered as a saver, although not a maker of proteid tissues. All starches are believed to have the same food value, the difference in cost having no relation to their nutritious qualities. If more starch is eaten than is utilized at once its elements are transformed into fat in the body and stored.

DIGESTIBILITY OF STARCHES.

All starches when well cooked are easily and thoroughly digested. Some are finer grained than others, such, for instance, as that found in arrowroot, which is sold under that name. These fine-grained starches are much prized and are more expensive than other common starches. They are more delicate in flavor and give cooked products of superior qualities. All starches, however, when pure are edible and digestible, and when unpleasant flavors are detected in dishes made from them it is owing to the fact that they have not been completely purified by the manufacturer. Cheap cornstarch is a good example of this, and so is laundry starch. Some laundry starches have also had soap added to them. Starch is an exceedingly valuable food material, as it is easily digested by most people and is found in so many of our common and inexpensive foods.

EXPERIMENT AND PRACTICE WORK, FOURTH LECTURE.

Sources of Starch.

Experiment 13. Materials needed.—Mortar and pestle, small pieces of cheese cloth, measuring cup, small bowls, test tubes and labels, test-tube holder, tincture of iodin, corn meal, oatmeal, tapioca, cabbage, turnip, green banana, apple, 1 ounce of beef, milk, 1 ounce of fish, rice.

Exercise.—Treat corn meal, oatmeal, tapioca, cabbage, turnip, green banana, apple, beef, milk, fish, and rice with cold water, as suggested in References No. 31, p. 68; No. 7, p. 15, to see if they contain starch. When starch is obtained put some of it into a test tube and label it plainly. When well settled pour off the liquid and dry the starch, keeping each kind by itself and plainly labeled.

Make a list of those foods which contain starch. (See also first lecture, Experiments 1, 2 (C), and 3 (C).) Do animal foods contain starch? Do all common vegetable foods contain starch?

Microscopical Examination of Starch.

Experiment 14. Materials needed.—A microscope with one-eighth-inch objective and No. 1 eyepiece, plain slides and cover slips, labels for slides, starch obtained from foods in Experiments 1, 2 (C), and 3 (C).

Exercise.—Mix a few grains of the different starches each in a teaspoonful of cold water. Put a drop of each on a plain slide labeled with the name of the starch. Cover with a cover slip and examine it under the microscope. Make a drawing of each one before examining the others. Is there a difference in size and shape in the different kinds of starch?

Chemical Properties of Starch.

Experiment 15. Materials needed.—One gram (15 grains) of cornstarch, cold water, glass funnel, tumbler, filter paper, iodin solution.

Exercise.—Mix starch and cold water. Filter and test the filtrate with iodin. Is starch soluble?

Experiment 16. Materials needed.—Cornstarch, tincture of iodin, flour, dextrin, stale bread, 1 lemon, a little malt flour, 2 test tubes, 1 test-tube holder, 1 cork or cotton to plug 1 test tube, 1 pie plate, a small white porcelain plate, a glass rod, a small saucepan, thermometer, a spoon, an oven, a toaster.

Exercise.—(A) Slowly heat a little starch in a plugged test tube. When light brown dissolve a little of it on a porcelain dish and test it with iodin. Compare the color obtained with that obtained with dextrin.

(B) To make dextrinized flour heat a few tablespoonfuls of flour on a tin plate in a hot oven. Stir frequently and spread the flour so that it will heat evenly. When it is all a very light brown take it from the oven. This can be used in feeding invalids, for making "thickened milk." Test a little of it with iodin. To what has the starch been changed?

(C) Cut stale bread in slices and toast it. (References No. 31, p. 88; No. 33, p. 67.) What substance is formed when toast is made?

(D) Boil one-half teaspoonful of starch in equal parts of lemon juice and water for one-half hour. Test it with iodin. What substance is formed?

(E) Test a little malt flour and water with iodin. Does it contain starch? Put a small amount in a test tube. Add 2 volumes of warm water to it and keep in a saucepan of water at 60° C. or 140° F. for twenty minutes or more. Test it with iodin. What substance is in malt which makes this change in starch?

Methods of Preventing Starch from Becoming Lumpy while Cooking.

Experiment 17. Materials needed.—Measuring cup, cornstarch, granulated sugar, boiling water, 4 small saucepans, 4 spoons, 2 small bowls, butter, milk, eggs, double boiler, 2-quart mold, egg beater, vanilla.

Exercise.—(A) Perform Experiment A in Reference No. 31, p. 69.

(B) Perform Experiment B, Reference No. 31, p. 70.

(C) Perform Experiment C, Reference No. 31, p. 70.

(D) As an application of the principles involved in B and C, make Rebecca pudding. (Reference No. 33, p. 344.)

(E) Mix 1 tablespoonful of melted butter, add 1 tablespoonful of flour, and when these are blended slowly add one-half cupful of hot water, stirring all the time until the mixture boils. Explain why it does not become lumpy.

(F) As an application of this principle make cream sauce (References No. 37, p. 64, or No. 33, p. 266) and serve it on the toast previously made.

FIFTH LECTURE—CEREALS USED AS BREAKFAST FOODS.

The most important cereal food products, because they are the most largely used, are those prepared from wheat, corn, rice, and oats. (References No. 26, p. 7; No. 50, p. 98.)

COMPOSITION OF CEREALS.

Cereals contain all five food principles. They average about two-thirds carbohydrates, one-tenth protein, another tenth water, and they contain a little fat and mineral matter. It will thus be seen that they are chiefly valuable as fuel foods, but the amount of protein they contain makes them also worthy of consideration as tissue builders. Since foods rich in protein are usually expensive, the cheapness of cereals makes the protein in them of particular importance. They can often be substituted to some extent for the more expensive protein foods, such as meat, eggs, etc.

In regard to the amount of protein they contain oats rank first, then wheat, corn, and rice last. (Reference No. 1, p. 244.) Those cereals richest in protein are poorest in starch, so that the order in which they would stand, according to the amount of starch in them, would be reversed, namely, rice, corn, wheat, and oats.

In comparing cereals with protein foods such as meat, account must be taken of the fact that cereals are not usually eaten in the dry state. The only fair basis of comparison, therefore, would seem to be the raw cereal plus the amount of water commonly added to make it palatable, or the cooked cereal. The table following compares cereal and other foods cooked by ordinary household methods. It must be remembered that the composition would vary with the proportion of water used in cooking.

TABLE 2.—*Comparison of 1 pound of representative cooked cereal foods and certain other foods.*

Kind of food (1 pound).	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Energy.	Cost per pound.
	Pound.	*Pound.*	*Pound.*	*Pound.*	*Pound.*	*Calories.*	*Cents.*
Cooked oatmeal	0.845	0.028	0.005	0.115	0.007	285	0.6
Cooked hominy	.793	.022	.002	.178	.005	380	.8
Cooked rice	.720	.020	.001	.244	.003	525	1.6
Beefsteak	.660	.203	.136		.011	950	20.0
Eggs, edible portion	.730	.134	.105		.010	720	
Milk	.870	.033	.040	.050	.007	325	3.5

It will thus be seen that none of the cereals correspond very closely with beef in composition, but that those which absorb the least water give the most nourishment as they are served on the table. Because it is drier, a saucer of cooked rice gives more nutriment than a similar quantity of oatmeal. The dry, ready-to-eat cereals would give more nutriment ounce for ounce than the home-cooked, moist ones, but not necessarily cupful for cupful, for the former are very light and bulky. If we compare them with the moist cereals before they are cooked, or if we compare the dry cereals moistened with milk or cream, as they usually are when eaten, with the home-cooked cereal we should find that one had not much advantage over the other.

DIGESTIBILITY.

The cereals as ordinarily prepared are not as thoroughly digested as meat. In general only 0.8 as much of the protein is digested as in beef, so that the following table will represent a truer comparison of the protein value of cereals and meat.

TABLE 3.—*Comparison of the approximate amount of total and digestible protein in 1 pound of cooked breakfast cereals and beef.*

Kind of food (1 pound).	Total protein.	Digestible protein.	Kind of food (1 pound).	Total protein.	Digestible protein.
	Pound.	*Pound.*		*Pound.*	*Pound.*
Cooked oatmeal	0.028	0.024	Cooked rice	0.020	0.017
Cooked hominy	.022	.019	Beef	.203	.197

The digestibility of all the breakfast cereals is about equal, except, perhaps, rice. On account of its small amount of fiber rice is commonly said to be more easily digested, although perhaps but little more thoroughly digested than the others. The breakfast cereals have about the same digestibility as bread, those with the bran retained being about like graham bread and those without the bran much like white bread. When much sugar is eaten with foods, digestive disturbances are often noted, therefore it is well to eat cereals without sugar or with only a moderate quantity. (Reference No. 26, p. 32.) Some persons substitute sweet fruits, like dates, for sugar, and such combinations are palatable and wholesome. The bran of cereals contains much mineral matter and protein. The hard particles of crude fiber it contains when ground or some other characteristic makes it irritating to the intestine, and, consequently, such food increases peristaltic action, though it lowers digestibility somewhat. It is apparently owing to this action and to the laxative effect of one of the ash constituents of bran that coarse foods containing it are so useful if there is a tendency to constipation. (Reference No. 26, p. 20.)

PREPARATION.

Although there are so many varieties of cereal breakfast foods on the market, most of them fall readily into one of four groups:

(1) Those prepared by simply grinding the grain, such as Scotch oatmeal, cracked wheat, or wheat grits.

(2) Those which have been steamed or otherwise cooked and then ground or rolled, such as the many commercial varieties of rolled oats, flaked rice, etc.

(3) Those which have been flaked or otherwise mechanically treated and parched so that they are ready to eat.

(4) Those which have been flaked or similarly treated and also acted upon by malt, which to some extent induces chemical changes in the starch, but the chief effect of which is to flavor the cereal, in spite of the fact that much more is often claimed for it. (Reference No. 26, pp. 10–12, 21.)

These groups differ most from one another in the amount of further preparation they require to render them suitable for the table. The first group will need a great deal of cooking and the second group will need less cooking, the exact time depending upon the amount of cooking given the cereal in the course of manufacture. Probably it is safe to say that the length of time suggested on the package is generally too short. As the majority of the ready-to-eat brands appear to have been cooked enough, the breakfast foods of the third group may be eaten as purchased, although such cereals are improved if heated enough to make them crisp.

Except in so far as the flavor is relished there is no special advantage for people in ordinary health in eating malted or so-called "predigested" cereals, as these are in no true sense predigested and, in any case, if properly cooked, the ordinary preparations can be readily digested by the average individual. (Reference No. 26, p. 22.)

COOKING.

The object of cooking the cereals is (1) to sterilize the material, (2) to improve the flavor and appearance of it, as a good flavor stimulates the flow of the digestive juices, and (3) to produce such changes in the structure and texture of the grains that the ease of digestion may be increased. Starch and the other nutrients are held in cells of woody fiber. Heat and water combined soften the fiber and rupture the cell walls so that the digestive juices can readily penetrate to the nutrients. The time of cooking required varies with the amount and character of fiber, the size of the pieces, and the degree of cooking which cereals may have had in the course of manufacture. Thus, coarse hominy requires longer cooking than fine hominy or corn meal; wheat grits than rolled wheat, oatmeal than rice. Corn preparations require longer cooking than any of the others, there being more fiber in corn. Wheat and oats are much alike in respect to the amount of cooking they require. Insufficiently cooked cereals are considered to be less easily digested than well cooked (Reference No. 49, p. 27), partly because the starch grains are surrounded with a mucilaginous proteid material. This condition disappears with long cooking. Boiling temperature affects the protein, making it somewhat more difficult of digestion. A long cooking at a lower temperature answers equally well for softening the fiber and cooking the starch (Reference No. 9, p. 378), and this method is indicated as the best one. A double boiler is almost a necessity when cereal breakfast foods are cooked on a stove. A hay box, or fireless cooker, is very convenient for cooking these foods. (Reference No. 3, p. 259.) With all cereals it should be remembered that overcooking is unusual and harmless, while undercooking is common and undesirable.

COST.

The cost of food depends not alone on the price per pound, but on the amount of nutrients contained in a pound and their digestibility. Those foods containing the most water and refuse have the least nutrients. Cereals contain little water and refuse, and those cereals which cost from 3 to 7 cents per pound are among the cheapest foods known. The increase in price in some cereals is not due to any increase in the nutrients or digestibility, but in the cost of

preparation. Corn products are the cheapest, oat preparations come next, and wheat next. Those cereals which come in small packages are as a rule more expensive than cereals bought in bulk. They are usually put up by large mills, where provision is made for cleanliness. Their tight coverings also prevent the entrance of insects and dirt while in the market. The fact that the manufacturer is directly responsible to the consumer for the condition of these goods is another advantage to the purchaser of package cereals.

The amount of fuel needed to cook cereals is a factor in their cost as food. It is well to cook them, if possible, when a fire must be maintained for other purposes and merely warm them when ready to use them, or to make use of some fuel-saving device such as a hay box. (Reference No. 26, pp. 27–30, 34–37.)

HOMEMADE BREAKFAST FOODS.

Any stale bread or cake may be dried and lightly browned in the oven, then crushed and eaten dry or with milk or cream as a breakfast cereal. Stale bread may be dipped in molasses and water and dried in the warming oven of an ordinary range from twelve to twenty-four hours and then crushed, to be used like the various granular breakfast foods. (Reference No. 26, p. 31.)

EXPERIMENT AND PRACTICE WORK, FIFTH LECTURE.

The following table shows the proportion of water and salt to cereal and the time required for cooking cereal foods of different sorts:

TABLE 4.—*Proportion of ingredients and time of cooking cereal breakfast foods.*

Description of cereal.	Cereal.	Water.	Salt.	Time of boiling.		Additional time of cooking in double boiler.
	Cups.	*Cups.*	*Teaspoons.*	*Hrs.*	*Mins.*	*Hours.*
Oatmeal, crushed, raw	1	4	1	--	10	8
Oatmeal, rolled, steamed	1	3	1	--	10	1½
Corn meal	1	4	1	--	10	3
Fine hominy	1	5	1	--	10	4
Coarse hominy (soak twelve hours)	1	10	2	4	--	1
Wheat grits, raw	1	5	1	--	10	4
Wheat, rolled, steamed	1	3	1	--	10	1½
Coarse, granular wheat preparations	1	6	1	--	10	¾
Farina	1	4	1	--	--	½
Rice (to be boiled)	1	12	2	--	20	----------
Rice (to be steamed)	1	3	1	--	5	¾ to 1

As shown by the results of a number of experiments which the author has made, cereal foods may be satisfactorily cooked in a hay box, or fireless cooker. Such a cooker may be readily made at home by following the directions given in one of the Farmers' Bulletins of this Department. (Reference No. 41.) The following table shows

the proportion of ingredients and the time required when cereal products of different sorts are thus cooked:

TABLE 5.—*Proportion of ingredients and time of cooking cereal breakfast foods in a hay box.*

Description of cereal.	Cereal.	Water.	Salt.	Time of boiling.	Additional time of cooking in hay box.
	Cups.	*Cups.*	*Teasp.*	*Minutes.*	*Hours.*
Oatmeal, crushed, raw	1	5	1.5	15	12
Oatmeal, rolled, steamed	1.5	4	1.5	10	10
Corn meal	1	4.5	1	3	6
Fine hominy	1	5	1	5	12
Coarse hominy (soak twelve hours)	1	12	2	60	13
Wheat grits, raw	1	5	1.5	30	12
Wheat, rolled, steamed	1.5	4	1.5	5	12
Coarse granular wheat preparations	1	7	1.5	3	12
Rice	1	4.5	2	3	2

Measuring.

The method of measuring adopted in this course is described in References No. 31, pl. 4, p. 54; No. 33, p. 28. In using different recipe books the method of measuring adopted by them should always be ascertained, as in many books the old-fashioned method of measuring by rounded spoonfuls is still used. A rounded spoonful is equal to two level spoonfuls.

Making a Hay Box.

Materials needed.—For a hay box with one compartment, 1 packing box, at least 18 inches long, 18 inches wide, and 20 inches high; $1\frac{1}{4}$ yards heavy muslin or denim, 2 large sheets of heavy manila paper, 1 paper of small tacks, 1 hammer, needle and thread, soft hay to fill the box.

Exercise.—Make a hay box, following the directions given in Reference No. 41, pp. 16–19. If the box be first lined with heavy paper, tacked on, dust and particles from the hay will not sift out readily. Soft hay is best for filling a hay box.

Hominy Mush.

Materials needed.—For hominy, salt, water, pail for use in the hay box, wooden spoon, measuring cup and teaspoon, dishes for serving, sugar and cream.

Exercise.—Prepare hominy mush following the directions given in Table 5 and Reference No. 31, p. 77, using a hay box. If a small quantity of hominy is to be cooked arrange the hay box as explained in the directions for making "Indian pudding," p. 59.

Rolled Oats.

Materials needed.—Rolled oats, water, salt, double boiler, wooden spoon, measuring cup and teaspoon, dishes for serving, sugar and cream.

Exercise.—Cook rolled oats following the directions given in Table 4, p. 32, and Reference No. 31, p. 77. Oatmeal gruel can also be made from rolled oats by the directions given in Reference No. 33, p. 500.

Wheat Breakfast Food.

Materials needed.—A granular wheat preparation, water, salt, measuring cup, teaspoon, silver knife, dates, double boiler, dishes for serving, cream, wooden spoon.

Exercise.—Cook the breakfast food by the directions given in Table 4, p. 32, and ten minutes before the cereal is done add a few dates which have been washed and pitted and cut in small pieces.

Food Value of Cereals.

Experiment 18. Materials needed.—A pair of scales, cereal cooked in class work, raw cereal of the same kind, pencil and paper.

Exercise.—When one of the cereals is cooked, weigh it. Weigh the quantity of raw cereal that it represents. From the table in Reference No. 26, pp. 14, 15, calculate the amount of this raw cereal that would have a fuel value equal to one-half pound of steak (which would be an ordinary liberal helping of steak). What proportion is this of the whole quantity of cereal cooked? Set aside an equal proportion of the cooked cereal and notice the quantity as it appears when cooked. Could it be served in one portion in a meal? What is the difference in character or food value of this amount of cereal and one-half pound of steak?

SIXTH LECTURE—CEREALS WHICH ARE USED AS VEGETABLES.

The cereal foods which are commonly used as vegetables are green corn, hulled corn, macaroni and other similar pastes, and rice.

CORN.

Old-fashioned hulled corn is made by steeping the kernels in a weak solution of lye to loosen the skins and then washing thoroughly. The coarse hominy is hulled by a different process. The directions for cooking coarse hominy are given in the fifth lecture, Tables 4 and 5, pp. 32, 33.

Green corn is one of the most nutritious of the fresh vegetables. When, as is usual, the kernels are eaten whole, the indigestible skins may interfere with the digestion of green corn. The central part of the kernel is, however, very easily digested, and if the kernels

are cut down the center with a sharp knife and the inner part pressed out the digestible part of the corn only will be eaten. In Table 6 it will be seen that the composition of green corn is very similar to that of potatoes.

TABLE 6.—*Showing the comparative composition of green corn, cooked hominy, potatoes (raw and boiled), cooked rice, and cooked macaroni.*

Kind of food.	Water.	Protein.	Fat.	Carbohydrates.	Ash.	Energy per pound.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Calories.*
Green corn, raw	75.4	3.1	1.1	19.7	0.7	470
Cooked hominy	79.3	2.2	.2	17.8	.5	380
Potatoes, boiled	75.5	2.5	.1	20.9	1.0	440
Potatoes, raw	78.3	2.2	.1	18.4	1.0	385
Boiled rice	72.5	2.8	.1	24.4	.3	525
Cooked macaroni	78.4	3.0	1.5	15.8	1.3	415

If corn forms a very large proportion of the dietary it is better to eat it in combination with milk than with sirup or sugar only, as it is rich in carbohydrates and deficient in protein. In planning meals containing corn it is well to introduce other foods that are rich in protein, such as eggs, milk, and meat. It would be a poorly planned meal in which the vegetables were potatoes and corn and the dessert made of rice or a pudding composed of cereal meals. Some pudding made of milk and eggs would be a better dessert with corn or rice used as vegetables. (Reference No. 1, p. 242.)

MACARONI.

Macaroni is made from wheat flour, ground from special varieties of wheat rich in gluten. The flour is mixed with hot water to a stiff dough and pressed by machinery, through cylinders perforated at the end to give it its characteristic form. It is then dried and, as all the water which has been added is evaporated, its composition is very similar to that of the wheat flour of which it is made. (Reference No. 12, p. 6.) It is somewhat more expensive than bread and slightly less digestible. Table 6 shows that it is between hominy and potatoes in fuel value. It is not only on account of its nutritive qualities that it is valuable in the dietary, but because of the variety of its satisfactory combinations with other food materials. Being deficient in protein, macaroni should be combined with cheese or meat to make a well-balanced dish. This fact need not be considered if some proteid food like meat or eggs be served at the same meal. When cheese is cooked with macaroni the dish has such high protein value that it is unnecessary to supply the usual meat ration in addition. It is thus seen to be a good partial substitute for meat. Chopped ham as a substitute for cheese makes a good combination for baked macaroni. Sauces are often made to pour over macaroni or tomatoes are cooked with it. (References No. 32, pp. 224–227; No. 33, pp. 90, 91.)

American macaroni is equal to that which is imported in composition and food value and its method of manufacture is usually said to be more cleanly. (Reference No. 12, p. 61.) Tests for good macaroni are (1) a creamy color, (2) breaking without splitting, (3) not losing its tubular shape nor growing pasty when cooked, and (4) swelling to nearly three times its bulk when boiled. (Reference No. 31, p. 118, 119.)

Noodles are similar to macaroni and other Italian pastes, except that when the dough is made eggs should be added, making the noodles richer in protein. Noodles can be treated in the same way as macaroni.

RICE.

Rice is thought to be best if not eaten until at least three months after harvesting. Some people consider it better after three years.

In the process of cleaning rice a considerable proportion of the grains become broken. These grains are separated from the whole kernels and sold at a cheaper rate. Their composition and food value will be just as great as that of whole kernels, but they will not make such a good appearance when cooked. Where strict economy is necessary they can be used to good advantage. American-grown rice is fully equal to Japanese rice in food value, but the nutrients are in slightly different proportions. Japanese rice contains a little more protein but less starch than American rice.

COOKING RICE.

When properly cooked rice should be thoroughly soft, but the kernels perfect in shape, not merged in a pasty mass. If rice is wet and sticky it is because it has been cooked too long, or in the case of steamed rice, with too much water added to it. Boiled rice will also be sticky if the water is allowed to evaporate so that what is left becomes thickened with starch and will not drain away completely. Broken rice is somewhat more likely to be sticky than whole kernels. Test whether the rice is cooked enough by biting through a kernel. If soft in the center, the rice is done.

EXPERIMENT AND PRACTICE WORK, SIXTH LECTURE.

Steamed Rice.

Materials needed.—Steamer and kettle to fit under it, bowl or custard cups to hold the rice, a piece of cheese cloth to fit over the top of the steamer, a fine colander, a double boiler, rice, salt, water, dishes for serving.

Exercise.—(A) Cook steamed rice in a double boiler by the directions in Table 4, p. 32.

(B) Cook steamed rice in a steamer. Use 1 teaspoonful of salt and 2 cupfuls of boiling water for each cupful of rice. Put all together, after washing the rice, in a bowl. Set the bowl in a steamer over rapidly boiling water. Cover the steamer with a thin cloth before putting on the tin cover to prevent water from condensing and dropping on the rice. Steam for three-quarters of an hour to an hour, or until the rice is soft. If each student makes steamed rice, use the recipe in Reference No. 37, p. 13, and have the rice cooked in custard cups.

Turkish Pilaf.

Materials needed.—Double boiler, fine colander, fork, cooked strained tomatoes, highly seasoned stock, rice, salt, pepper, butter, dishes for serving.

Exercise.—Cook Turkish Pilaf II by the directions in Reference No. 33, p. 90. This dish can also be made in a hay box, but the proportion of liquid must be increased by one-half cupful.

Boiled Rice.

Materials needed.—Rice, water, salt, colander, large saucepan, dishes for serving, oven, tin plate.

Exercise.—Boil rice according to the data in Table 4, p. 32. When the rice is tender drain it into a colander and stand the colander on a tin plate in the oven with the door open for five minutes. Serve it in a hot dish. If each student boils rice, use the rule in Reference No. 37, p. 13.

Poor Man's Rice Pudding.

Materials needed.—Rice, sugar, milk, baking dish, oven, serving dishes.

Exercise.—Make poor man's pudding by the directions given in Reference No. 34, p. 335.

Baked Macaroni and Cheese.

Materials needed.—Large saucepan, colander, baking dish, grater, one 2-quart saucepan, one 1-quart saucepan, measuring cups, teaspoons, tablespoons, case knife, macaroni, cheese, stale bread, butter, milk, flour, salt, pepper, serving dishes.

Exercise.—Boil macaroni in a large amount of boiling water to which has been added a teaspoonful of salt for every quart of water. If macaroni is soaked in cold water for several hours it will boil in less time than if unsoaked. If it has not been soaked it will require about forty minutes. Drain in a colander when it is very soft and white. Make baked macaroni and cheese by the directions given in Reference No. 33, p. 90, using one cupful of thin white sauce (Refer-

ence No. 33, p. 237), one-half cupful of grated cheese, and one cupful of buttered crumbs for each pint of cooked macaroni. Buttered crumbs are made by crumbling the inside of stale, but not hard, bread and adding to each cupful one-eighth teaspoonful of salt, a dash of pepper, and one tablespoonful of melted butter. Stir the crumbs into the butter until they are evenly buttered. Do not use the crusts of bread in scalloped dishes; save them to be dried and ground fine for use on fried food.

Planning Menus Containing Cereals.

Materials needed.—Notebooks and pencils.

Exercise.—Plan menus using either rice, coarse hominy, fried mush, green corn, or macaroni. Try to make an attractive and balanced meal. These may be discussed by the class.

SEVENTH LECTURE—BREAD.

THE INGREDIENTS.

The ingredients used in making bread are flour, liquid, yeast or some leavening agent, fat to make the bread less tough, and salt to season it. Sugar is often added to improve the flavor and aid the yeast growth. Excess of sugar, fat, or flour makes dough dense, so that it will not expand as quickly as otherwise. For this reason more yeast must be used in mixtures that are very " short " or very sweet. Bread flour should be used in mixtures raised by yeast; lard or butter may be used for the fat; soft water is better than hard, but it must be as pure as for drinking purposes or the dough will be likely to turn sour or spoil. Any ordinary kind of yeast will raise bread. The question of yeast and flours will be taken up later. If whole or skimmed milk is used the bread will be more nourishing than when the dough is mixed with water. It also has a different texture and whiter color than water gives it, and when whole milk is used the fat in the milk has the effect of adding " shortening." (Reference No. 16, p. 341.)

THE PROCESS OF MAKING BREAD.

For a description of the process see Reference No. 6, p. 349. Recall Experiment 2 (B) in the first lecture to explain the influence of kneading upon gluten.

The time required for the process of making bread depends upon the amount of yeast used and the temperature of the dough during the rising.

The Mixing.

The more thoroughly the mixing is done the better the product will be, and, although much kneading will cause bread to take longer to rise, the improvement in texture makes up for this disadvantage. The use of a bread machine is to be recommended, as it is a more cleanly way of making bread than kneading by hand and saves time. (Reference No. 16, p. 344.) When using the machine the temperature of the dough may be a little higher than when using the hands, as the machine absorbs heat from the dough instead of adding heat to it, as the hands do. This will make more difference the larger and more cumbrous the machine. Bread may also be mixed with a knife if a bread machine is not available.

Table 7 shows the proportion of liquid to flour required for bread mixtures of different consistency.

TABLE 7.—*Approximate proportions of liquid to flour to make bread mixtures of different consistency.*

Kind of flour mixture.	Liquid.	Flour.
	Cupful.	*Cupfuls.*
Batters	1	1
Muffin or cake mixtures	1	2
Dough to knead, as bread dough	1	3
Stiffer dough, as for cookies or pie crust	1	4

Batters can be mixed with a spoon, doughs more easily with a knife. In some cases bread is made into a batter at first by adding only a part of the flour. This is allowed to rise before adding the remaining flour, and is called a "sponge." The different ways of making bread cause different flavors. The kind of yeast accessible, the particular meal for which hot bread is wanted, or the convenience of fitting in the making of bread with other cooking or housework are the factors which usually decide the method adopted.

The Rising.

The temperature of the dough should be kept from the mixing to the baking between 70 and 90° F., unless a sponge is set overnight in which case it must be kept somewhat cooler. Dough is allowed to rise at least twice—once after mixing and again after shaping. If sponge is set, this is allowed to ferment until well filled with bubbles, and the dough then made is usually allowed to rise twice more. Sponge, by reason of its liquid consistency, may not double in size when sufficiently fermented, but dough, being stiffer, can be tested in this manner, for it has risen enough when it has doubled in bulk.

Molding and Shaping.

The form and size of a loaf make a difference in the time and temperature of baking. It is desirable that bread be made into loaves not more than 4 inches broad, as the heat will penetrate such a loaf evenly and quickly. Cake or raised pudding which is to be cooked in shallow or small pans will not need to be so stiff as if cooked in a large deep pan. Breads which must be kneaded before shaping will have to be stiff, no matter how small the shape when baked.

Baking.

The heat of the oven should be greater for small-sized molds, such as rolls, cakes, etc., baked in gem pans or thin layers, than when large loaves are to be baked. The temperature of the oven before the bread is put in should depend partly on the quantity of bread being made. If a large number of loaves are to be baked at once they will cool the oven somewhat, and this must be allowed for.

Dividing the time of baking into three equal periods, the temperature of the oven, for baking medium-sized loaves of bread, should be about 300° F. or 150° C. at the beginning, increased to not more than 325° F. or 160° C. for the middle period, and gradually decreased again to the original temperature during the third period. Such loaves will require from fifty minutes to one hour for baking. (References No. 16, p. 350; No. 10, pp. 28, 29.)

EXPERIMENT AND PRACTICE WORK, SEVENTH LECTURE.

The Ingredients of Bread and the Effect of Varying Them.

Materials needed.—Small bowls, knives, measuring cup and spoons, sieve, bread boards, thermometers, small bread pans, oven, straight flour, salt, sugar, lard or butter, compressed yeast, whole milk, skimmed milk, flour dredgers.

Exercise.—Each student should make a small loaf of bread, using a larger proportion of yeast than ordinarily, so that the whole process may come within the available time. Some loaves are to be made with water, some with whole and some with skimmed milk. Varying quantities of fat are to be used and in one loaf no fat is to be used. Except for these changes the loaves are to be made alike, to show the effect of shortening and other variations on the texture, etc. Use compressed yeast and straight flour and give the bread two risings. The recipe given in Reference No. 37, p. 61, may be used for all loaves except those in which the fat is to be experimented with.

Detailed Process of Making Bread.

Scald milk, if it is used, to kill any bacteria that it may contain. Cool it to blood heat or less; add to it the melted fat, sugar, salt, and yeast softened in warm water. Then add gradually enough sifted flour to make a dough which can be kneaded. If the flour is very cold, warm it to about 70° F. Knead it on a floured board until it is smooth and elastic. When kneaded enough it will quickly rebound if pressed with two fingers. Return it to the mixing bowl, moisten the top with warm water, milk, or melted fat to prevent a dry crust from forming, cover it with a clean folded towel or cloth, and keep it in a warm place (about 100° F.) until it has doubled in size. Then put it on a board and knead it again to break all the large bubbles and distribute the new yeast plants. It is kneaded enough when it stops squeaking or cracking, or, when cut through the center with a knife, no large holes are seen. Mold it into loaves, put it into greased bread pans, and let it rise again until it has doubled in size. Bake small loaves, such as are used for class work, twenty-five or thirty minutes, using a thermometer in the oven. (Reference No. 31, pp. 130, 131.)

NOTE.—During the rising of the bread the other experiments may be performed.

Calculating the Nutrients in Bread Made from Various Materials.

Materials needed.—Pencil and paper, a pair of scales, fat like that used in making the bread.

Exercise.—(A) From the table in Reference No. 8, p. 55, calculate the difference in nutritive value of loaves of bread made with whole milk, skimmed milk, and water, allowing one-half pound (one cupful) of liquid to each loaf.

(B) Weigh four times the quantity of fat that was used in each loaf made in this lesson (as the small loaves were one-fourth the usual size) and calculate the difference in food value in an ordinary loaf of bread made with each quantity of fat.

To Prove what Gas is Formed During the Rising Process.

Experiment 19. Materials needed.—Flask, rubber stopper, glass tube, molasses, limewater, beaker or tumbler.

Exercise.—Perform Experiment B (Reference No. 31, p. 127), using molasses and water in which to grow the yeast.

Experiment 20.—Smell of the bread dough when it has risen light and is removed from the bowl to be molded into loaves. What substance do you detect by its odor?

EIGHTH LECTURE—YEAST AND MOLDS.

WHAT IS YEAST?

The confusion of mind resulting from calling so many different materials yeast can be cleared up to some extent when we consider what these different materials really are. Compressed yeast, dry yeast, hop yeast, liquid yeast, etc., are in reality mixtures of several substances, only one of these substances being yeast.

Yeast is a plant too small to be seen with the naked eye, consisting of one cell, which can be cultivated as any plant can, and will grow and reproduce very rapidly if given favorable conditions. (References No. 38, p. 4; No. 17, pp. 59–62.) The action of yeast in a medium favorable to its growth is called fermentation. (Reference No. 10, p. 16.) Other microscopic plants will grow in foods, if proper conditions exist, producing in some cases fermentation, in others putrefaction. (Reference No. 38, p. 2.)

REQUIREMENTS FOR GROWTH.

Like other fungus plants, yeast requires for growth (1) warmth, 75 to 95° F. being the most favorable temperature; (2) moisture; (3) food, which consists of a small quantity of nitrogenous matter, mineral matters, and sugar. Yeast does not grow in pure sugar, but practically any food which contains sugar also contains enough of the other substances to support the life of yeast plants (Reference No. 17, p. 66); and (4) oxygen, which it gets from the air, when it is supplied freely, and from sugar when air is deficient. The growth of the yeast results in change of the sugar, breaking it up and forming alcohol (experiment and practice work, Lecture No. 7, Experiment No. 20) and carbon-dioxid gas (Reference No. 30, pp. 127–129; experiment and practice work, Lecture No. 7, Experiment No. 19). It is to obtain this gas, which renders dough porous, that we use yeast.

Diastase, which is naturally present in flour, will change some of the starch in dough to sugar. By reason of this fact food for yeast is always available in dough. The presence of a considerable quantity of the products of yeast growth seems to check its further development and in time will cause it to lose its vitality, so that unless fresh material be added it will not continue indefinitely to form gas. If kept too long the plants finally die. If given somewhat unfavorable conditions the plant will not grow in its usual way, by division which may be called putting forth buds, but will form spores, which will afterwards grow and produce plants if given the right conditions. (Reference No. 10, pp. 17–19.)

CONDITIONS THAT AFFECT FERMENTATION.

(1) Organic acids, such as malic and tartaric acids, assist fermentation with yeast, but check fermentation with bacteria.

(2) Mineral acids, such as sulphuric and nitric acids, prevent fermentation.

(3) Alkalis arrest fermentation due to yeasts and molds, but not that due to bacteria.

(4) Boiling hinders and, if prolonged, prevents fermentation.

(5) Low temperature retards fermentation, but does not destroy the organisms of fermentation.

(6) Salt, in excess of about 1 part to 100 of the water used in bread making, retards or completely checks yeast fermentation. Salt also hinders bacterial fermentation.

(7) Hops check bacterial fermentation, but do not materially affect yeast fermentation. The action of hops is due to the presence in them of tannin. (Reference No. 38, pp. 13, 14.)

(8) Yeast and bacteria cause fermentation more quickly in cooked flour than in raw, as the starch is then more easily attacked owing to the softening influence of cooking.

(9) Cooked potatoes stimulate and hasten yeast fermentation.

(10) Water in which potatoes have been boiled also stimulates yeast growth, but in slightly less degree than cooked potatoes.

(11) A lively growth of yeast tends to check bacterial fermentation.

COMMERCIAL MANUFACTURE OF YEAST.

(1) The microscopic plants are sown in vats filled with a liquid mixture which acts as a food for yeast; (2) the new plants rise to the top with the foam formed and are skimmed off, the first skimmings being discarded because of their bad flavor; (3) the later skimmings, which are of better flavor, are washed and the water partly removed; (4) the washed material is mixed with starch, flour, or other material, and (5) pressed into cakes, if sold in solid form. For dry yeast the process is concluded by carefully drying the cakes at a low degree of heat, meal being used instead of starch or flour in the fourth process described above. For compressed yeast the yeast plant is usually grown in a sweetened liquid. Brewers' yeast is used in fermenting malt for beer; distillers' yeast is used in fermenting material such as rye, corn, barley, etc., which is later distilled for whisky. The flavor of bread made with brewers' yeast is different from that made with compressed or distillers' yeast, often imparting a bitter taste to bread. This can be prevented by washing the yeast in cold water, allowing it to settle, and pouring off the water. (References No. 17, p. 79; No. 14, p. 183.) Brewers' yeast in its growth softens the gluten, thus injuring the bread-making qualities of a good flour.

COMPRESSED YEAST.

Tests for Fresh Yeast.

The cake should be firm, a little moist, but not sticky nor putty like, creamy colored, when broken should show a fine fracture, and when a little is placed on the tongue it should melt readily in the mouth with no acid odor or flavor. It should have no cheesy smell. (References No. 38, p. 5; No. 14, p. 189.)

Care of Compressed Yeast.

The plants in the yeast cake begin to die in a day or two and after three or four days only a few living plants may be left unless the yeast is kept under very favorable conditions. Bacteria or wild yeasts then become active and the yeast cake decays. Even before the cake decays these other growths may multiply enough so that when planted in the dough they would produce undesirable flavors. If yeast must be kept several days place it in cold water and keep it in the ice chest, but do not let it freeze. (Reference No. 17, p. 80.)

DRY YEAST.

Drying kills some of the yeast plants but not all. In time more of the plants die, and the longer yeast of any kind is kept the fewer living plants it contains. In dry yeast the plants are in a dormant or spore state and it takes longer for them to start active fermentation than for plants in the active state, as found in compressed yeast. To aid their development it is well to soak the cake for a time in warm sweetened water. (References No. 17, pp. 81, 82; No. 38, pp. 5, 9.)

HOMEMADE YEAST.

As yeast is a plant and can not be made by human hand the process described as "making yeast" is in reality the preparation of a good soil for yeast to grow in and the sowing of the yeast plants in that soil. The soil or "brew" consists of either a cooked or raw mixture of flour and water, potatoes and water, or meal and water, with the addition, perhaps, of salt and, in some cases, extract of hops or malt. When stock yeast is added to this brew the yeast is "planted." If kept warm the plants reproduce rapidly and all signs of fermentation follow. As potatoes have a very stimulating effect in the growth of yeast, but not so with bacteria, and as hops have a decidedly retarding effect upon fermentation with bacteria, but not so with yeast, it would seem that a good brew would be one made with potatoes and hops. (Reference No. 38, p. 10.)

Use equal parts of homemade yeast and liquid in making bread, if the dough is to rise by the short process; and one part of yeast to two parts of liquid if the dough is to rise over night. (Reference No. 15, p. 343.)

SALT RISING BREAD.

When the brew is prepared but no stock yeast or old raw dough (leaven) is added, it will still be found that in time the mixture will ferment if kept warm. This spontaneous fermentation is due to the fact that yeast spores, when dried, are very light and are blown about so that they are present almost everywhere. These floating spores may be those of the household yeasts or those of "wild" yeasts which are common, for instance, in drying fruit, etc., but which are not often cultivated. The spores can enter the brew from the air or from the utensils used in mixing. When accidentally planted they grow, as any yeast would, and produce fermentation. Fermentation may also be the result of the natural presence of ferments or enzyms in flour. (Reference No. 20, p. 1301.)

Along with the wild yeast obtained in this method of making bread there are usually also obtained a large number of bacteria, which form bodies of characteristic odor and flavor in the course of their fermentation, and to this is due the peculiar odor and flavor of salt-rising bread. (Reference No. 17, p. 73.)

The uncertainty of this method of making bread is one of its disadvantages, but when it is made often in the same place the wild yeast most successful in raising this kind of bread is apt to be more abundant in the air, utensils, etc., than other wild yeasts. (Reference No. 38, p. 16.)

MOLDS.

Molds are minute plants, more complex in structure than yeast. They propagate by means of spores which are very small and light and blow about freely and are found nearly everywhere. As soon as they find conditions favorable they grow, attacking many kinds of food and producing great changes in their composition and flavor. In some cases, as in certain kinds of cheese, this is a desirable effect, but in most cases it is undesirable. (Reference No. 29, p. 123.)

Molds do not grow readily in direct sunlight, and even diffused light checks their growth to some extent. They require food and moisture and grow more readily in stale, stagnant, damp air than in fresh air, which is a valuable preventive for moldiness. (References No. 17, pp. 33–39; No. 18, p. 363.)

EXPERIMENT AND PRACTICE WORK, EIGHTH LECTURE.

The Growth of Yeast.

Experiment 21.—Effect of temperature on the growth of yeast.

Materials needed.—Molasses, water, three test tubes, labels for test tubes, compressed yeast, salt and ice unless in freezing weather.

Exercise.—Perform Experiment A in Reference No. 31, p. 126.

Experiment 22.—Microscopical examination of yeast.

Materials needed.—A microscope with one-eighth inch objective and No. 1 eyepiece, plain slide, and cover slip.

Exercise.—Follow the directions given in Reference No. 31, p. 125, for examining yeast cells.

Hop and Potato Yeast.

Materials needed.—Hops, potatoes, water, two saucepans, strainer, small piece of cheese cloth, measuring cup, scales, mixing bowl, wooden spoon, glass preserving jar, compressed yeast.

Exercise.—Make yeast No. 1, Reference No. 17, p. 83. Potatoes must be carefully washed before boiling and peeled before being mashed. (Reference No. 38, p. 12.) When the yeast is made put it into a preserving jar and keep it in a cool place. (Reference No. 34, p. 63.)

Wild Yeast "Emptins."

Materials needed.—Corn meal, milk, salt, sugar, small mixing bowl, spoon, measuring cup, pan of hot water.

Exercise.—Scald one-half cupful of corn meal (ground by the southern method, if possible) with three-fourths cupful of boiling milk or water. Add 1 teaspoonful salt. Set the bowl containing it into a pan of hot water (about 110 to 115° F.), and place it where it will keep at that temperature. When well filled with bubbles it is ready to use.

Dry Yeast.

Materials needed.—Flour, dry yeast, water, saucepans, salt, mixing bowl, wooden spoon, measuring cups and spoons.

Exercise.—Soak 1 cake of dry yeast in a pint of warm water for one-half hour. Add 1 pint of sifted flour, 1 teaspoonful of salt, 1 tablespoonful of sugar, and let it stand in a warm place till full of bubbles. Scald 3 pints of milk or water, add 3 teaspoonfuls of salt and 2 tablespoonfuls of lard or butter, and, when lukewarm, the yeast mixture. Add enough flour to make a batter and beat it very thoroughly. Let it stand in a warm place for eight or ten hours, usually over night, then add enough flour to make a dough that can be kneaded, and proceed as with any bread made by the "slow process."

Oatmeal Muffins.

Materials needed.—Cooked oatmeal, eggs, butter, milk, flour, salt, sugar, mixing bowl, wooden spoon, measuring cup and spoons, gem pans, oven.

Exercise.—Make oatmeal muffins according to the directions given in Reference No. 33, p. 73.

NINTH LECTURE—A STUDY OF WHEAT FLOUR.

Cereals used in bread making must have certain properties. For leavened bread gluten is essential, and wheat is the most important cereal containing gluten. Chemically it is a mixture of two proteids, gliadin and glutenin. When wet; gluten becomes viscid and is tenacious enough to hold gas. Rye also contains a gluten, other common cereals do not. Cereals without gluten may be mixed with wheat or rye and used for making leavened bread. For unleavened bread, such as Jewish "unleavened bread," hoecake, and crackers, any cereal can be ground to meal and used. (Reference No. 6, p. 348.)

STRUCTURE.

As will be seen by the diagrams (Reference No. 10, pp. 7, 8), the wheat grain proper, after husks and outer layers are removed, is composed of (1) the germ, embryo, or chit, (2) the endosperm, consisting of aleurone and the floury, central part, and (3) the bran or inner coverings of the seed.

The different parts of a kernel of wheat are composed of cells, varying in form and structure, but too small to be seen without a microscope. Each cell is inclosed by a cell wall of cellulose of which the thickness and character vary in different parts of the grain. Within each living cell is a network of nitrogenous material, called protein. Products formed by the plant, such as starch and fat, are stored in the portions of the cells not filled by protein. The character of the cell contents varies considerably in different parts of the seed, starch and gluten being characteristic of the interior of the grain rather than the outer portions. (References No. 10, pp. 7, 8; No. 15, pp. 61–63.)

COMPOSITION.

The contents of the cells are, then, (1) protein compounds, which are the tissue building materials of our food, found in the endosperm, chief of which are cerealine or aleurone and the two proteids gliadin and glutenin which unite to form gluten; (2) the carbohydrates, principally starch and sugars found mainly in the endosperm and serving to produce energy for warmth and muscular work; (3) the fats, occurring principally in the germ and being valuable to the

body as fuel; and (4) mineral matters found most abundantly in the bran and providing material for bones, teeth, etc. (Reference No. 10, pp. 9, 10.)

VARIATIONS IN WHEAT.

The conditions under which wheat grows and, still more, the variety of wheat grown affect the character of the cell contents greatly. Wheat from different parts of the country and Canada varies considerably. (References No. 25, p. 277; No. 34, pp. 152–154.)

Spring wheat is hard, contains a large proportion of gluten, and makes a good bread flour. Winter wheat is usually softer, especially that grown in the southwestern part of the country, contains a large proportion of starch, is deficient in gluten, and yet, though not so good for bread making, is better than spring wheat for making pastry and cakes and mixtures raised with baking powder, producing articles of a more tender, delicate texture. Soft winter wheat when milled is usually called pastry or St. Louis flour.

MILLING.

The wheat grain is ground differently according to the product desired. In low milling, as it is called, the grain is ground between two stones or rollers set as near together as possible. Graham flour is commonly produced in this way. In high roller milling the grain is washed and tempered. After removal of the bran the stock is run through five or more pairs of rollers, each successive pair being set nearer together than the last pair. After each grinding the fine flour is sifted out and the leavings of each sifting, called "middlings," are themselves ground and sifted several times. (References No. 10, p. 11; No. 15, pp. 64–68; No. 12, p. 11; No. 40, pp. 21, 22.) Several grades of flour are thus produced and a great number of different products.

VARIETIES AND GRADES OF FLOUR.

(1) Graham flour consists of all the grain coarsely ground and unbolted. An imitation graham flour is sometimes sold which is made from a mixture of milling products. Winter wheat is usually used for such flour, as the bran layer is not so hard and irritating to the digestive organs as that found in spring wheat. Graham flour is not, therefore, as rich in protein as a high class patent flour. (Reference No. 15, p. 64.)

(2) Entire-wheat flour, if true to name, is made by removing the bran from hard wheat and grinding the remainder of the grain, but as a matter of fact the entire-wheat flours on the market are often a mixture of patent flour, low and middling grade flours, with considerable of the germ. Entire-wheat flour is not so coarse

as graham flour and contains about one-half per cent more protein than straight or standard flour, considerably more mineral matter, and about two and one-half times as much fiber. (Reference No. 15, pp. 69, 70.)

(3) White flours are of various grades. The highest grade flour is called first patent. It has the greatest power of expansion of any flour and is rich in gluten. The grade most commonly used is standard patent or straight flour. This is a mixture of first patent, second patent, and first clear. (References No. 13, pp. 7, 8; No. 15, p. 66.) It has excellent expansive powers (Reference No. 13, pl. 1), is rich in protein, and makes a white loaf with good flavor and keeping qualities. (Reference No. 6, p. 358.) Pastry or St. Louis flour is milled like high-grade bread flours and differs from them according to the difference in composition between soft winter wheat and spring wheat. (Reference No. 40, p. 22.)

(4) A number of flours are on the market which are called gluten flours and sold for the use of persons who are compelled to limit the amount of starch in the diet. Some of these are made by washing wheat flour until more or less of the starch is removed, drying, and grinding the gluten which remains, and if of good quality may be fairly called true to name. Others appear to be nothing more than flour ground by the ordinary process from wheat without any special preparation. (Reference No. 46.)

(5) There are a number of pancake and pastry flours on the market which are "self-rising," that is, which do not require the addition of baking powder. Such goods consist of mixtures of flour or meal, as the case may be, and baking powder, with salt and perhaps sometimes other seasoning. They are often convenient to use, but the products made from them are not in any way superior to those made from flour and leavening materials by the ordinary domestic methods. (Reference No. 47, p. 94.)

DIGESTIBILITY OF DIFFERENT FLOURS.

The digestibility of bread seems to depend largely on the character of the flour from which it is made. The patent flours have been found by many experiments made in this country and abroad to yield more nutriment to the body than flours containing more or less bran because they are more thoroughly digested. This means that whether the other flours contain more nutriment or not, and it is not true that they always do, they do not yield all their nutriment to the human body. (References No. 10, p. 36; No. 13, p. 36; No. 15, pp. 65, 66.)

The following table shows the proportion of digestible protein and carbohydrates in flours of different sorts (References No. 6, pp. 358–361; No. 12, p. 10):

TABLE 8.—*Proportion of the digestible nutrients found in different flours.*

Kind of flour.	Protein.	Carbo-hydrates.
	Per cent.	*Per cent.*
Graham	75	89
Entire wheat	82	94
Standard patent	89	98

Coarse particles of bran make bread more indigestible than if the bran is finely ground. (Reference No. 13, pl. 1.)

BREAD-MAKING QUALITIES OF FLOURS.

This depends not only upon the quantity of gluten, but still more upon its character. (Reference No. 11, p. 38.) Gluten is composed of two substances, gliadin and glutenin, quite different in character, which when moistened cling together and form gluten. Glutenin is a granular material forming nearly one-third of good gluten. Gliadin is sticky and acts like glue in binding together the particles of glutenin. (Reference No. 6, p. 349.) The proportion of the two which makes the best gluten, viz, that giving the most expansion possible, is 65 per cent gliadin to 35 per cent glutenin. (Reference No. 6, p. 351.) Bread made from flour deficient in gliadin lacks expansive powers; where gliadin is in excess the dough is soft and sticky. (Reference No. 5, pl. 2.) If the total gluten in flour is deficient but its character is good the bread will be nearly as good as from a flour rich in gluten. (Reference No. 5, pl. 2.) If the total gluten is in excess the bread does not become lighter but rather the reverse, showing that in normal flour from good spring wheat the proportion of gluten and starch is best for bread making. (Reference No. 13, pl. 3.) The other proteids in flour have little effect on its bread-making properties. (Reference No. 11, p. 41.)

EXPERIMENT AND PRACTICE WORK, NINTH LECTURE.

Household Tests for the Quality of Wheat Flour.

Experiment 23. (A) *Gluten test. Materials needed.*—Samples of flour, scales, five squares of cheese cloth, 10 by 10 inches, five small bowls.

Exercise.—Test for the amount and quality of gluten according to the directions given in References No. 11, p. 40, and No. 25, p. 276, using for comparison bread or spring-wheat flour, pastry or winter-wheat flour, graham, entire wheat and gluten flours. Record the

results. A dark, stringy or putty-like gluten is of little value for bread-making purposes.

(B) *Granulation.*—Grasp a handful of good spring-wheat flour in the hand. Do the same with pastry flour. The bread flour should fall apart easily; the pastry flour will hold the impress of the hand. (Reference No. 16, pp. 339, 340.) Bread flour will have a granular feeling if rubbed between the fingers; soft winter-wheat flour feels smooth.

(C) *Color test.*—High-grade flour should be white or slightly creamy. Dark-colored, slaty, or gray flours are of poor quality, indicating a low grade of flour, poor milling, or poor quality of gluten. After being on the market a short time flour bleaches a little and improves in color to a slight extent. Some flours have been specially bleached to improve their color, but in general color is a good means of testing flour. Choose a standard brand of first patent grade flour for making a comparison of bread flours.

(D) *Absorption test. Materials needed.*—A good brand of first-patent flour, soft-wheat flour, a pair of scales, small bowls, standard flour.

Exercise.—Test flour by its powers of absorbing water. Flour with good bread-making characteristics will absorb 60 to 65 per cent of its weight of water. Flours of low absorption make less bread and the bread dries more quickly than that made from flour with high absorption. (Reference No. 16, p. 340.) Add a measured and weighed amount of water to a measured and weighed amount of standard flour, pastry, or soft-wheat flour. Record and compare the results.

Extracting Gliadin from Flour.

Experiment 24. Materials needed.—Sample of flour, flask, stopper for flask, alcohol, water bath and evaporating dish or small double boiler, hydrochloric acid.

Exercise.—Extract gliadin from flour by the directions given in Reference No. 25, p. 277. Treat a little white of egg in the way suggested for the filtrate obtained. Notice that on adding alcohol to flour, dough is not formed, but merely a sandy, damp mass, because only one of the gluten constituents, gliadin, is soluble in alcohol, and gliadin alone will not give a sticky, tenacious dough.

Graham Bread.

Materials needed.—Bowl, spoon, measuring cup, bread pans, materials named in formula.

Formula.—One and one-half cupfuls warm water, 2 tablespoonfuls molasses, 2 tablespoonfuls fat, 2 teaspoonfuls salt, one-half cake of compressed yeast softened in one-fourth cupful warm water, 1½ cupfuls white flour, 2½ or 3 cupfuls graham flour or enough to make

a stiff batter. Beat it until thoroughly mixed, smooth and elastic. Let it rise until very light, beat it again, and pour it into two greased pans. Let it rise until double its size and bake it one hour.

NOTE.—During the time of rising of the bread made in this lesson perform the experiments for testing flour and analysis of flour, and make egg toast.

Egg Toast.

Materials needed.—Stale bread, 2 eggs, 1 cupful milk, salt, butter, griddle, tin plate, measure cups and spoons, plates and silver for serving.

Exercise.—Make egg toast by the rule in Reference No. 34, p. 76, using 2 eggs in place of one, or each student preparing one slice and using one-fourth egg, one-eighth cupful milk, and one-eighth teaspoonful salt.

Bread with Potato Yeast.

Materials needed.—Flour, milk, salt, sugar, lard, bowl, spoon, measuring cup, bread board, bread pans.

Exercise.—Make bread using the potato yeast that was set in the practice work, Lecture 8. Follow the directions in Reference No. 34, p. 64. Double the quantity of yeast or use three times the amount to make the process come within a few hours.

Rolls.

Mold half the above dough into rolls (Reference No. 34, pp. 69–71). Have each student mold one or two shapes, but do not have all mold the same, so that as great a variety as possible may be made.

Entire-Wheat Bread.

Materials needed.—Entire-wheat flour, straight flour, milk or water, yeast, lard, sugar, salt, bowl, bread board, bread pans, measuring cup and spoon.

Exercise.—Make entire-wheat bread using the rule in Reference No. 33, p. 58, or the rule for entire-wheat and flour bread on page 59.

Salt Rising Bread.

Materials needed.—Flour, milk or water, salt, sugar, lard, wild or virgin yeast, bowl, pan to set bowl in, thermometer, measuring cup, spoons, bread board, flour, dredger, bread pans.

Exercise.—Make salt rising bread using the yeast prepared in Exercise 8. Yeast made with one-half cupful of liquid will raise four loaves of bread. Make a sponge, adding the wild yeast (see p. 46). Keep the sponge in a bowl set in as hot water as you can bear your hand in (about 110° F.). When light, add flour to make a dough, knead, mold, and, when the loaves have doubled in size, bake.

Gluten Wafers.

Materials needed.—Gluten flour, cream, salt, bowl, spoon, measuring cup, bread board, grater, rolling pin, baking sheets.

Exercise.—Make gluten wafers using one-half cupful of cream, one-half teaspoonful of salt, and about 1⅓ cupfuls of gluten flour. Add the salt to the cream, then add enough flour to make a very stiff dough. Knead it until smooth and roll it so thin that you can see the grain of the board through it. Prick it well with a fork or press with the rough surface of a grater. Cut into shapes and bake in a hot oven until a delicate brown. If desired to have each student make wafers use one-eighth cupful cream, one-eighth teaspoonful salt, and about one-third cupful gluten flour.

TENTH LECTURE—A STUDY OF RYE, CORN, BUCKWHEAT, AND OTHER FLOURS.

RYE.

Rye is similar to wheat in composition, being the only other common cereal that contains a gluten, but it makes darker bread and less porous than wheat, owing to the difference in the character of its gluten. Rye flour is cheaper than wheat flour, and mixed with wheat flour makes bread of good quality. It has no greater nutritive qualities than other cereals, but is valuable because of the variety it gives to the menu. It is found that when the menu is varied and the appetite thereby increased that food is the more completely digested. (References No. 6, p. 348; No. 10, pp. 13, 16.) Leaven is frequently used to raise rye bread, but leaven is apt to produce a sour loaf with rye or any flour.

CORN MEAL AND FLOUR.

The structure of a grain of corn is similar to that of wheat. (References No. 25, p. 289; No. 10, p. 14.)

Composition.

The composition of corn is compared with other cereals in Lecture No. 5, p. 28. Yellow and white corn meal are very much alike in composition, any difference in flavor, if present, being due to the method of milling.

Milling.

The milling of corn is different in the Southern States from that in the Northern. The southern-made meal is of two grades; one, ground coarsely between stones and sifted through a coarse sieve, contains all of the grain except the coarse bran; the other, finely ground and bolted through a fine sieve, loses nearly all of the bran and therefore

contains less fiber and mineral matter. The germ, which is left in southern-made meal, makes it spoil easily, as the corn oil of the germ soon becomes rancid. The flavor and action in cooking of this meal are also quite different from that milled in the North. (Reference No. 20, p. 1277.) In the northern process the germ is first removed and artificial heat is used in the course of milling so that the meal keeps better. It has an even granular consistency quite different from southern meal. (Reference No. 20, p. 1278.) As corn does not contain gluten it must be combined with wheat or rye flour when used for bread raised with yeast.

BUCKWHEAT.

Buckwheat contains less protein than wheat and about the same as rye. Buckwheat does not contain gluten and it is therefore not adapted for making loaves of bread, though it may be used with baking powder or soda and sour milk to make biscuit. In making the flour the fiber is largely removed. It is more frequently adulterated than any other flour, and its adulteration can be best detected by microscopic examination. The dark color imparted by a portion of the hulls, which are usually retained in milling buckwheat, is an indication of its purity. This is not an infallible test, however, as rye flour if mixed with buckwheat will also impart a dark color to cakes. (Reference No. 20, p. 1174.)

OTHER MEALS USED IN BREAD MAKING.

It is interesting, though not of general practical use, to know that meals or flour are made from a number of vegetable products besides cereals. Chestnuts can be hulled and ground and form a flour very similar to corn meal in composition. Flour is made from bananas and from soy beans: some nuts also, notably the almond, can be ground and used to make a kind of biscuit. These are, of course, only used under exceptional circumstances. Flour is also made by drying and grinding a number of tropical roots and tubers, as cassava and taro.

EXPERIMENT AND PRACTICE WORK, TENTH LECTURE.

Rye Flour.

Experiment 25.—Extracting gluten from rye flour.

Materials needed.—Small bowl, small piece of cheese cloth, rye flour, pan of water, spoon.

Exercise.—Extract the gluten from rye flour in the same manner as from wheat flour. (Experiment No. 23, p. 50.) Compare its amount and character with that previously obtained from wheat.

Rye Bread.

Materials needed.—Mixing bowl, measuring cup and spoons, knife, bread pans, bread board, rye flour, wheat flour, milk or water, lard, sugar, salt, yeast or leaven.

Exercise.—Make rye bread by the directions in Reference No. 33, p. 57, or use leaven to raise it according to the directions in Reference No. 10, p. 24.

Corn Meal Breads.

Materials needed.—Corn meal, flour, eggs, milk, salt, sugar, butter, baking powder, gem pans, cake cooler, mixing bowl, wooden spoon, measuring cup, teaspoon, tablespoon, oven.

Exercise.—(A) Make corn muffins, following the directions in Reference No. 31, p. 112. If desired one-fourth cupful of sugar may be added and the dough may be baked in shallow pans. This is called "johnny cake."

(B) Make corn pone and hoecake instead of corn muffins, if the school is in a locality where southern-ground meal can be obtained.

Buckwheat Cakes.

Materials needed.—Mixing bowl, wooden spoon, measuring cups and spoons, buckwheat flour, milk, water, sugar, salt, compressed yeast, litmus.

Exercise.—(1) Set a buckwheat batter to rise over night, using 1 cupful of milk, 1 teaspoonful of sugar, 1 teaspoonful of salt, one-fourth cake of compressed yeast dissolved in one-fourth cupful of warm water, or one-half cupful of liquid yeast and about 1 cupful of buckwheat flour. Test with litmus before baking. Bake some of the dough. Add three-eighths of a teaspoonful of soda to each cupful of the remaining dough. Test with litmus. Bake this dough and compare these cakes with those raised by yeast only.

(2) Make buckwheat cakes, using the same ingredients as in No. 1 omitting the yeast and using in its stead 1 teaspoonful of baking powder.

Note.—These are to be mixed just before baking and in order to compare them with Nos. 1 and 3 they may be made in Exercise 11, p. 59, when Nos. 1 and 3 will be completed.

(3) Set buckwheat batter to rise over night with the same ingredients as in No. 1, omitting the yeast. Just before baking add three-eighths of a teaspoonful of baking soda for each cupful of batter. What part do you think the soda plays in making buckwheat cakes? Does batter No. 3 differ materially from No. 2? What part does yeast play in making buckwheat cakes?

Bread Puddings.

Materials needed.—Stale bread, milk, eggs, butter, sugar, chocolate, vanilla, baking dishes, double boilers, measuring cups and spoons, oven.

Exercise.—Make bread pudding by the rule in Reference No. 33, p. 330, and chocolate bread pudding by the rule on page 331. Discard the crusts in making the plain pudding though they may be used for the chocolate pudding. If it is possible to have each student make an entire pudding use the rule in Reference No. 37, p. 51, for the chocolate pudding and for the plain pudding the following ingredients: One-fourth cupful of hot milk, one-eighth cupful of soft bread crumbs, one-fourth tablespoonful of butter, one-fourth egg (yolk and white), one-half tablespoonful of sugar, 5 drops of vanilla.

ELEVENTH LECTURE—CHANGES PRODUCED IN THE CONSTITUENTS OF BREAD.

CHANGES DURING RISING.

The greatest change in the constituents of bread that takes place during the rising is in the carbohydrates, and almost exclusively in the sugar. (Reference No. 20, p. 1317.) Owing to the action of ferments, naturally present in the flour or produced by the yeast plants, a considerable portion of the starch is changed to sugar. The action of yeast also causes some sugar to be completely broken up, and of its elements the two substances alcohol and carbon-dioxid gas are formed. These, being volatile, are lost.

The proteids are changed in character, but there is little loss of protein. These changes are produced (1) by the yeast plant, which requires nitrogenous food. As they can make use of nitrogen compounds that are not proteids very little protein is thus lost. (2) Bacteria also feed upon nitrogenous matter, but the principal change which they effect in the proteids is the softening or rendering soluble of some of the insoluble proteids. This is due partly to ferments which they secrete and partly to the action of acids which they form, both of which have a softening effect upon a part of the gluten. Acids, naturally present in the flour to a slight extent, also aid in this softening of the gluten. When the gluten is thus changed it is materially injured for bread-making purposes, as it loses its elastic qualities to a considerable extent, and thus will not hold the gas formed. Sour dough will sometimes be seen to sink or " fall " after becoming light owing to this fact. (Reference No. 5, pp. 19–21, 33.)

THE SHORT PROCESS VERSUS THE LONG PROCESS.

By the "short process" is meant setting the bread, for instance, in the morning, with a large enough quantity of yeast to raise the bread in four or five hours. By the "long process" is meant setting a sponge usually over night and letting the sponge and dough have a total of twelve or fifteen hours for rising. During the long process organisms, ferments, and acids have time to accomplish a greater amount of change in the dough. The loss of nutrients in the short process need not exceed more than 1.5 or 2 per cent, whereas in the long process it may be as high as 6 or 8 per cent. (References No. 6, p. 352; No. 5, p. 34.) Bread made by the long process has been found to have twice as much acid formed as that made by the short process. On the other hand, if care is taken to prevent the dough from becoming too warm and the other necessary precautions are observed, the dough need not sour. It is frequently convenient to have the bread baked as early in the day as is possible, and considerable time is gained by allowing the first rising to take place over night. The decision as to the method pursued must rest on the question whether materials or time are most to be economized in each individual case.

CHANGES WHICH TAKE PLACE DURING BAKING.

The proteids are coagulated, and so they are presumably a little less easily digested than when in liquid form. The starch grains in the crumb are ruptured and cooked, making the starch more digestible. In the crust the starch is dextrinized (Lecture 4, Topic 4 B, p. 25, and Experiment 19, p. 41) and partly caramelized. The fat in the crust is changed somewhat, but the digestibility of the bread is not much affected by this, as fat is not present to a large extent. Volatile substances, such as alcohol formed by the yeast plant, are driven off by evaporation. Not as much water is lost as would appear by contrasting an apparently dry piece of bread with the moist, sticky dough, for much of the water has been chemically combined with the gluten and will be retained by it even when the bread becomes quite stale. Carbon dioxid passes out of the loaf and is replaced by air. The yeast is killed by the heat of the oven in well-baked bread and usually all other organisms also. (Reference No. 6, p. 349, paragraphs 1, 2.)

STALE BREAD.

When bread is kept for any length of time the air-cell walls shrink and adhere together more closely than at first. Little water is lost, but it combines chemically with the solid portion, so that the bread appears drier than when fresh. This makes it necessary to chew it more before swallowing, and this thorough mixing with saliva, as well

as the fact that it does not gum up when chewed, may account for the easier digestibility attributed to stale bread.

If stale bread is placed in the oven a short time some of the water turns to vapor and expands the cell walls again, making the bread appear moist and very like fresh bread. (Reference No. 7, p. 172.) The greater amount of moisture originally in bread the longer it keeps its moist, fresh character.

While the acid in fresh bread is less than that in dough, as bread is kept the acid sometimes increases again. (Reference No. 5, p. 21.) The forming of acid in bread after baking is probably due to the fact that the spores of some acid-forming bacteria will resist the heat of the center of a loaf of baking bread for an hour and if favorable conditions for growth occur they will develop in the bread.

USES TO WHICH STALE BREAD MAY BE PUT.

Making (*a*) toast (Reference No. 32, p. 67), (*b*) soft crumbs for scalloped dishes (Reference No. 34, p. 75), (*c*) dry crumbs for covering fried food (Reference No. 34, p. 75), (*d*) griddle cakes (Reference No. 33, p. 79), (*e*) puddings (Reference No. 33, pp. 330, 331), (*f*) stuffing for fish (Reference No. 34, p. 163), and meat or poultry (Reference No. 34, p. 258), (*g*) croustades (References No. 33, p. 321; No. 16, p. 353), (*h*) croutons and soup sticks (References No. 33, p. 130; No. 16, p. 353), (*i*) omelets (Reference No. 33, p. 99), (*j*) homemade breakfast cereals (Reference No. 26, p. 31), (*k*) muffins and griddle cakes (Experiment and practice work, Lecture 11, p. 59), (*l*) bread (Experiment and practice work, Lecture 12, p. 63), (*m*) cake (Reference No. 32, p. 472).

THE CARE OF BREAD.

The causes of spoiling are (1) the growth of bacteria in the loaf forming acids or, in rare cases, ropiness (Reference No. 10, p. 31); (2) the growth of molds (References No. 10, p. 31; No. 17, pp. 32–39); (3) the evaporation of water, leaving the bread dry and hard.

To avoid trouble due to these causes cool bread quickly (Reference No. 10, p. 29) and keep it cool in a clean, tightly covered receptacle. The bread box or crock must be sterilized occasionally (Reference No. 10, p. 32) by letting it stand full of boiling water in which a little sal soda (sodium carbonate) has been dissolved, or by exposing the whole interior to direct sunlight for several hours after a thorough washing. This is to kill bacteria and molds which will surely find their way in time into the receptacle, and unless it is well cared for will grow and multiply, attacking the bread and causing it to spoil.

EXPERIMENT AND PRACTICE WORK, ELEVENTH LECTURE.

Freshening Stale Bread.

Materials needed.—One loaf stale bread, 1 slice of stale bread for each student, 1 oven, 1 steamer and kettle, 1 cup, plates for serving, butter for serving.

Exercise.—Freshen a loaf of stale bread by placing it in a moderate oven for 15 minutes, or until heated through. Freshen slices of stale bread according to the directions given in Reference No. 34, p. 76.

Stale Bread Muffins.

Materials needed.—Stale bread, milk, egg, flour, salt, sugar, baking powder, butter, gem pans, mixing bowl, spoon, double boiler, measuring cups and spoons, oven, plates and knives for serving.

Exercise.—Soak 2 cupfuls of stale bread (crust and crumb) which has been cut in small pieces in 1 cupful of scalded milk. When well softened, beat the mixture until it is smooth, then add one-third cup of water, 1 egg, and 1½ cupfuls of flour to which has been added one-half teaspoonful of salt, 2 tablespoonfuls of sugar, 4 teaspoonfuls of baking powder. When these are blended, add 1 tablespoonful of butter, melted, and bake in ten greased muffin pans from 25 to 30 minutes. If only crusts are used, the muffins will be dense and too moist; if only crumb is used, the muffins will be better than when any crust is used, but a mixture of crust and crumb in the proportion found in the loaf will give satisfactory results.

Stale Bread Griddle Cakes.

Materials needed.—Stale bread, milk, butter, eggs, flour, salt, baking powder, buckwheat batter started in Lesson 10, baking soda, a griddle, salt pork or other fat to grease the griddle, teaspoons, tablespoons, measuring cups, knives, one fork, and plates, knives, and forks for serving.

Exercise.—(A) Make stale bread griddle cakes by the rule given in Reference No. 33, p. 79, or, if possible, have each student make them using the rule in Reference No. 37, p. 68.

(B) Make buckwheat griddle cakes, using the batters started in the practice work of the tenth lecture.

Indian Pudding.

Materials needed.—A hay box, one 6-quart and one 2-quart covered agate pail for the hay box, Indian meal, molasses, ginger, milk, salt, teaspoon, measuring cups, saucers and spoons for serving.

Exercise.—Make Indian pudding using 2½ cupfuls of water, 4 cupfuls of milk, two-thirds cupful of Indian meal, 2 teaspoonfuls of salt,

1 teaspoonful of ginger, 1 cupful of molasses. Boil all the ingredients together for 10 minutes and cook in a hay box over night. Fill the outer pail partly full of boiling water and put the small pail inside of it. The hot water serves as a source of heat. Serve the pudding hot.

Care of Bread Box or Crock.

Materials needed.—One bread box or crock in which bread has been kept, washing soda, boiling water, direct sunlight for several hours.

Exercise.—Wash the receptacle, scald it or put it in the sun. (Lecture 11, paragraph 4, p. 58.)

Study of Molds.

Materials needed.—One magnifying glass, 1 microscope one-sixth inch or one-eighth inch objective and No. 1 or No. 2 eyepiece, a piece of moldy bread, 2 inoculating needles, a microscope slide (plain) and cover slip, a hard pencil, and paper.

Exercise.—(A) Examine mold under a magnifying glass. Draw a picture of it, showing mycelium or thread-like stems and spore cases (black dots).

(B) Examine a small portion taken up with needles and mounted in water on a plain slide. Make a drawing of what you see. Notice the opening spore cases.

TWELFTH LECTURE—COST OF BREAD, CAUSES OF IMPERFECTIONS, FANCY BREADS.

COST.

The price of bread varies greatly in different localities and often bears little relation to its food value, and no very close relation to the cost of the materials. The cost of bread is, on an average, about double the price of the materials, not including fuel for baking. Where a fire, such as gas, gasoline, or oil, must be maintained merely to heat the oven for bread the price of the fuel should be included. Where a coal or wood fire is maintained for other purposes as well as bread making there is greater economy in baking at home. When possible different processes involving the use of a fire should be carried on at the same time, so that while the oven is in use for baking the top of the stove is used for boiling or heating irons, etc.

Three pounds of flour will make a little over 4 pounds of bread. By obtaining the local retail prices for flour the price of each loaf can easily be estimated not including fuel for baking. With flour at 3 cents a pound, materials for bread cost about 3 cents a loaf, unless milk is used. (References No. 15, p. 76; No. 19, pp. 392, 393; No. 10, p. 39.)

Table 9 shows the relation between the cost of the digestible nutrients in white bread and some other common foods at certain assumed values per pound.

TABLE 9.—*Cost of digestible nutrients in bread and other foods at certain assumed values per pound.*

Material.	Total digestible nutrients in 1 pound.	Assumed average cost of 1 pound.	Number of pounds that will furnish the same amount of digestible nutrients as 1 pound of bread.	Cost of the amount that will furnish the same digestible nutrients as 1 pound of bread.
		Cents.		*Cents.*
White bread	0.621	6	1.00	6.00
Graham bread	.569	6	1.09	6.54
Entire-wheat bread	.565	6	1.10	6.60
Beefsteak	.328	18	1.89	34.02
Potatoes, raw	.207	1.5	3.00	4.50
Dried peas	.824	7	.75	5.25
Dried beans	.796	6	.78	4.68
Macaroni	.856	12	.72	8.64
Crackers	.889	5	.70	3.50

CAUSES OF IMPERFECTIONS IN BREAD.

(A) Large holes in bread may be caused by (1) lack of kneading. The holes will coalesce in time and if the dough is well kneaded the second time these will be kneaded out. (2) If allowed to ferment too long acids which develop in the dough, or are normally present in the flour, will act upon the gluten, softening it and thus reducing the tenacity of the flour so that bubbles will tend to coalesce more than normally. (Reference No. 5, p. 33.) Gas will also be lost and bread not as light as if fermented the proper length of time, which is until the dough doubles in size. (3) Too moist a dough (seen often in beaten bread). This causes a hole that is of the nature of a crack or fissure. (4) Baking in an oven which is too hot, especially at the first. This causes holes just under the crust.

(B) If the bread crumbles instead of cutting cleanly under the knife it is said to be due to the use of harsh, dry flours, or to being overworked, i. e., fermented too long.

(C) Bitter bread may be caused by partly spoiled grain or an abnormal fungus growth in the flour, or by using brewers' yeast.

(D) Heavy bread may have several causes. (1) The commonest is insufficient rising. (2) Underbaked bread may be heavy. (3) Poor yeast is also a cause of this failure. (4) Poor, weak flours, deficient in gluten, can not make light bread, as the flour lacks tenacity to hold the bubbles of gas evolved during fermentation. (5) Awkward handling of the risen dough when ready for the oven, by reason of which the bread is jarred, causing the bubbles to break and the gas to escape.

(E) Sour bread is caused by the growth of acid-forming bacteria. This growth is most vigorous after the yeast growth begins to decrease. Therefore, overfermentation is one cause of sour bread. It is very likely to sour if made in unclean utensils, as they contain bacteria left from former bread making and a large number are thus "planted" in the dough. Keeping the bread too warm tends to increase the growth of bacteria. (Reference No. 18, pp. 362, 363.)

(F) Lack of care after bread is baked may cause moldy or ropy bread. (Reference No. 18, pp. 364, 365.)

BUNS AND OTHER SWEET BREADS.

Buns and other sweet breads raised by yeast are very similar in composition and in the process employed in making them. As they contain much more sugar and shortening than ordinary bread they require a longer time to rise. (Lecture 7, paragraph 1, p. 38.) Particular care must therefore be taken to allow them to become light enough before baking them. When sufficiently risen they will be fully twice their original size.

Bun dough can be molded into a variety of shapes and used for plain buns, cinnamon buns, hot cross-buns, brioche, coffee cake, and raised doughnuts, although slightly different formulas are usually given for these different breads.

EXPERIMENT AND PRACTICE WORK, TWELFTH LECTURE.

Cost of Bread Compared with Other Foods.

Materials needed.—Pencil and paper and notebook.

Exercise.—The lecturer should suggest problems for the pupils to work out regarding the cost of nutrients in some common foods, such as eggs, milk, oatmeal, or rice, at current local prices as compared with the price of bread (use Reference No. 8 for obtaining the composition of these foods). Pupils should also compute the cost of the materials for white bread at local prices. Compare the result with the above prices and make a table of results similar to Table 9 in Lecture 12, p. 61. This work can be carried on while the breads made in this lesson are rising.

Buns.

Materials needed.—Milk, butter, flour, yeast, sugar, powdered cinnamon, dried currants, eggs, salt, mixing bowl, spoon, gem pans, bread board.

Exercise.—Make buns, using the following recipe, with several times the amount of yeast given in order to hasten the rising enough to permit it to be accomplished in the time devoted to this lesson.

Recipe for Buns.

Make a sponge of 1 cupful of milk, three-eighths cupful of sugar, 1 egg, one-fourth teaspoonful of salt, one-fourth cake of compressed yeast, softened in one-fourth cupful of warm water, 2 cupfuls of flour. Follow the directions in Reference No. 34, p. 74, for the remainder of the process.

Cinnamon Buns.

Materials needed.—The quantity of bun dough which the above recipe makes, dried currants, brown sugar, butter, powdered cinnamon, gem pans, pastry board, rolling pin, knife.

Exercise.—Roll the bun dough into a rectangular sheet one-fourth inch thick. Spread it with one-half cupful of butter (softened), 1 cupful of washed and dried currants, 2 tablespoonfuls of cinnamon, and 1 cupful of brown sugar. Roll the dough as in making jelly roll. Cut the roll into 1-inch lengths. Turn these up on their sides and place them in greased gem pans. When very light bake them in a moderate oven for 45 minutes. After they have baked 20 minutes pour one-half teaspoonful of molasses over each bun. Repeat this at the end of 30 minutes.

NOTE.—Double the quantity of bun dough in the above recipe should be set to rise over night and extra yeast added in the morning when the sponge is made into dough, one-half to be used for buns and one-half for cinnamon buns.

Bread Made with Stale Bread.

Materials needed.—Stale bread, milk, salt, sugar, lard, flour, yeast, double boiler, mixing bowl, knife, spoons, and cup for measuring, bread pans, bread board, oven, cake cooler.

Exercise.—Cut off the crusts from stale bread, cut the crumb into small pieces and cook with an equal measure of scalding hot milk or boiling water in a double boiler for 10 minutes. Cool the mixture until lukewarm. The bread and milk or water may then be treated as plain milk or water would be in making bread, the only difference in the recipe for this bread and any other being that less flour will be required to make a dough.

THIRTEENTH LECTURE—BREAD RAISED BY OTHER AGENTS THAN YEAST.

GAS OBTAINED BY THE USE OF CHEMICALS.

Acids and Soda.

An acid from the chemist's standpoint is a body which will combine chemically with alkaline substances to form a salt. The common acids are all sour substances and will turn certain blue vegetable colors

red (illustrate with litmus). Acids also turn red cabbage water violet; alkalis turn it green.

Baking soda, called also bicarbonate of soda, is an alkaline substance. When an acid is added to soda bubbles are formed and a neutral substance results, which is neither an acid nor an alkali, and which is called a salt. The bubbles are carbon-dioxid gas—the same as that formed by yeast. Any acids will cause this gas to be formed when added to soda, but some acids leave injurious compounds and some, such as vinegar, are found in connection with material that would give an objectionable taste to food. Any harmless acid which does not leave an unwholesome compound or an undesirable flavor could be used with soda to raise breads. Some acids, however, are specially adapted to the purpose, causing the formation of gas quickly enough for convenience and not so quickly as to allow of its being dissipated before the food can be cooked, as is the case with hydrochloric acid. (Reference No. 16, p. 346.)

Carbonate of Ammonia.

Carbonate of ammonia is a very volatile substance and when heated in dough is all turned to gas and steam, so that there is no residue. It is not often used alone at the present time to raise breads or cakes, but is used by bakers to neutralize sour dough. When combination with an acid takes place an ammonium salt is left in the dough. This practice is not desirable, as it is considered unwholesome to have this salt in dough.

Baking Powders.

Baking powders are made of soda and some substance containing an acid. There are three general classes on the market.

(1) Tartrate powders, which are made of soda and cream of tartar (which contains tartaric acid) in the right proportions, with about 20 per cent starch added to separate the grains of soda and cream of tartar, so that they will not combine readily before being put into the dough. (References No. 7, p. 158, paragraph 12, and No. 20, pp. 1304, 1305.)

(2) Phosphate powders, which are made of soda and acid phosphate of lime (which contains phosphoric acid). Reference No. 20, pp. 1306, 1307.)

(3) Alum powders, which are made of soda and alum (which is a sulphuric acid salt which acts as an acid). (Reference No. 20, pp. 1307–1309.) Some powders are made containing more than one acid, as it is thought that this increases their efficiency. (Reference No. 7, p. 163.)

Substitutes for Baking Powders.

Soda combined with an unobjectionable acid may be used as a substitute for baking powder. As an excess of soda renders breads unwholesome and injures the flavor, and an excess of acid makes them sour, it is necessary to know the right proportion in which to combine the soda and acids. This varies with different materials. The proportion of soda to several acids or acid containing materials which will give the greatest amount of gas (Reference No. 16, pp. 346, 347), and leave a minimum of soda or acid behind is as follows:

Amount of baking soda and acid required for leavening.

1 teaspoonful soda requires 2 teaspoonfuls cream of tartar.

1 teaspoonful soda requires 1 cupful thick sour milk.

1 teaspoonful soda requires 1 cupful molasses.

1 teaspoonful soda requires scant one-fourth cupful normal hydrochloric-acid solution (78 cubic centimeters of concentrated hydrochloric acid in 1 liter of water constitutes normal hydrochloric acid).

In substituting cream of tartar and soda for baking powder use soda in the proportion of one-third the total baking powder, measuring it quite scant, and use cream of tartar in the proportion of two-thirds of the amount of baking powder.

In substituting soda and sour milk for baking powder pay no attention to the amount of baking powder in the recipe but use one teaspoonful of soda to each cupful of sour milk. If molasses and sour milk are both used, take one teaspoonful of soda to each cupful of sour milk plus molasses. In using hydrochloric acid use soda in the proportion of one-third of the amount of baking powder, and to each teaspoonful of soda add one-fourth cupful, scant, of normal hydrochloric-acid solution which may be prepared by diluting 78 cubic centimeters concentrated hydrochloric acid with 1 liter of water.

When baking soda is moistened and heated a considerable quantity of carbon-dioxid gas is given off without the addition of an acid. It is thus seen that if a greater proportion of soda be used than that which will be neutralized by the acid an additional amount of gas will be available. The residue left after moistening and heating baking soda is carbonate of soda, commonly known as washing soda. If eaten in large amounts this may have a deleterious effect on the digestion. Whether the increased lightness of the breads would not increase their ease of digestion so much that the ill effect of a small amount of carbonate of soda would be counterbalanced may be open to question. An excess of soda gives the bread an undesirable yellow color and an unpleasant taste. The effect of any residue is, of course, increased when breads raised by chemicals form a large part of the diet.

BREAD RAISED BY AIR.

Air may be introduced into dough to make it porous. When the dough is heated the entangled air is expanded causing the dough to rise. Aerated bread is made by forcing carbon dioxid into dough mechanically. It lacks the flavor produced by the other products of fermentation. (References No. 6, p. 353; No. 9, p. 194; No. 10, p. 29.) A familiar example of bread raised by air is found in beaten biscuit. (Reference No. 16, p. 345.)

EXPERIMENT AND PRACTICE WORK, THIRTEENTH LECTURE.

Effect of Acid on Soda.

Experiment 26. Materials needed.—Bicarbonate of soda, vinegar, sour milk, cream of tartar, molasses, acid phosphate of lime, ammonia alum, normal solution of hydrochloric acid, cold and hot water, ten thin glass tumblers or beakers, ten teaspoons, limewater, flask, rubber cork fitted with bent glass tube.

Exercise.—Put into nine of the glasses one-half teaspoonful of soda. Have nine students each take a glass. Two students take cream of tartar, one portion of which is dissolved in cold water, and the others one of the acid substances, vinegar, sour milk, acid phosphate of lime, ammonia alum, or hydrochloric acid. Have the class watch while each one in turn adds a little of the acid substance to the soda, which may first be dissolved in a little warm water. The cold cream of tartar solution should be added to soda which has been dissolved in cold water. The other lot of cream of tartar is to be dissolved in hot water and added to the soda, which must also be dissolved in hot water. Compare the rapidity of their chemical action under the influence of heat and cold.

In a flask, fitted as described in Reference No. 30, p. 127, add boiling water to one-half teaspoonful of soda and observe if any gas is given off. Add cream of tartar to this soda when no more gas is coming off and observe what gas is formed by the action of acids on soda and by the application of heat and water to soda.

Problem.—How much soda and cream of tartar should be used in place of the baking powder in the following recipes? (1) One pint of flour, 4 teaspoonfuls of baking powder, 1 cupful of milk, salt, and shortening. (2) Five cupfuls of flour, 7 teaspoonfuls of baking powder, 2 cupfuls of milk, salt, and shortening. How much soda and sour milk would be used as a substitute for the baking powder and sweet milk? (Lecture 13, paragraph 6, p. 65.)

Household Test for Adulteration of Baking Powder with an Excess of Starch.

Experiment 27. Materials needed—Tartrate baking powder of a reliable brand, tartrate powder of another brand, two 6-inch test tubes, water.

Exercise.—Boil 1 teaspoonful of a standard brand of baking powder for 1 minute in 1 teaspoonful of water in a test tube after the gas has ceased to come off. Do the same with the other brand to notice if the liquid is the same thickness. If thicker the powder had an excess of starch. This will show if there has been any considerable addition of starch.

Test for the Efficiency of Various Baking Powders.

Experiment 28. Materials needed.—A fresh sample of a standard brand of tartrate, phosphate, and alum powders, three glasses, flour, water, measuring cups.

Exercise.—Three students each make a batter of one-fourth cupful of flour into which has been thoroughly mixed one-half teaspoonful of one of the powders and one-eighth cupful of warm water. These must be mixed at the same time and very quickly and thoroughly beaten and then allowed to stand in a warm place for half an hour. The powder which raises the batter highest is the most efficient.

Biscuit.

Materials needed.—Pastry flour, butter or lard, baking powder, thick sour milk, sweet milk, baking sheets or plates, rolling pin, pastry board, flour dredger, mixing bowls, knives, teaspoons, tablespoons, and measuring cups.

Exercise.—Make biscuit using the rule in Reference No. 33, p. 70 or 71, or, if possible, have each student make them using the rule in Reference No. 37, p. 66. In this case have some students use baking powder and sweet milk, some use soda and cream of tartar, some soda and sour milk. Have the liquid all water in some, half milk and half water in others, and let some students use butter, some lard, and some half and half of each for shortening. Compare the results.

Maryland Beaten Biscuit.

Materials needed.—Flour, lard, salt, milk, water, pastry board, rolling pin, flour dredger, mixing bowl, knife, teaspoon, tablespoon, measuring cup.

Exercise.—Make beaten biscuit by the rule given in Reference No. 38, p. 77.

Note.—Have bun dough made after the recipe on page 63 set to rise at night to be used next day in making raised doughnuts, or set a sponge as described in Reference No. 33, p. 82 for "raised doughnuts."

FOURTEENTH LECTURE—COOKING IN DEEP FAT.

THE FAT USED.

The fat used for deep frying may be lard, rendered beef, or fresh pork fat, the better grade commercial culinary fats, cotton-seed oil, or a mixture of any of these fats. Rendered mutton fat has a strong flavor, and is not satisfactory for cooking. Fats rendered from salt or smoked meats are not suitable for deep frying and butter burns too easily to admit of its use. When the fat has been used carefully, viz. not allowed to become too hot, or when nothing of very strong flavor has been cooked in it, such as fish, it may be clarified (References No. 33, p. 23; No. 30, p. 218) and used again and again. Each time it is used, however, it scorches a little and some bits of the foods which are cooked burn brown, and even though the amount of such changes is so small they are not noticed at the time the fat will finally become brown and strong flavored and is then no longer fit for cooking, but may be used for making soap.

THE TEMPERATURE.

For frying uncooked mixtures, such as doughnuts and batters or raw potatoes, etc., fat should not be so hot as for frying materials which have been previously cooked, such as croquettes, or for frying foods that require but little cooking, such as oysters. The temperature of fat for frying is 360° to 400° F. Test fat with a thermometer constructed for such use or with a piece of bread as described in References No. 33, pp. 22, 23; No. 51, p. 74.

If fat becomes overheated it changes chemically, separating into other compounds, among which are glycerin and fatty acids and an acrid body called acrolein, which is very noticeable, as it makes the eyes smart. Some of these bodies, particularly acrolein, are irritating to the body and it is probable that the unwholesomeness attributed to fried food is in part due to the fact that fat is so often overheated in the course of frying. (References No. 31, p. 216; No. 43, pp. 85, 86.)

The temperature should be maintained throughout the frying, for the food will become greasy if the fat is cooled. (Reference No. 43, p. 100.)

PREPARATION OF FOOD FOR FRYING.

Many foods are dipped in dried bread crumbs and egg before frying. This forms a coating over the food, holds it together, and keeps out the grease. Foods to be thus treated should be covered with sifted dry bread crumbs (Reference No. 34, p. 75) dipped in egg which has been beaten a little and mixed with a tablespoonful of cold water, and again rolled in the crumbs. Except for sweet food the crumbs should be seasoned with a little salt and pepper. (Reference No. 33, p. 23.)

CARAMELIZATION.

The browning of foods is due to the fact that at certain temperatures foods become slightly burned or charred, a change which may be called the first stage of combustion, and which in the case of sugars is known as caramelization. Sugars, for instance, on being heated to 420° F. change in color and flavor. A chemical change has taken place in the sugar, and water, formed from oxygen and hydrogen of the sugar, has been separated from it and at the same time caramel has been formed. A similar change takes place in starch when heated to a high enough temperature (Reference No. 44, pp. 91, 92, and No. 31, p. 70, paragraph 126.) The chemical structure of caramel and the reactions involved in the formation of caramel are known, but are too complicated for study in this connection.

EXPERIMENT AND PRACTICE WORK, FOURTEENTH LECTURE.

Tests for the Temperature of Fat.

Experiment 29. Materials needed.—Three pounds of fat for frying, a Scotch frying bowl, pieces of stale bread, a cooking thermometer which will register 500° F. or more, butter, rendered beef fat, lard.

Exercise.—Perform the experiments in Reference No. 31, pp. 216, 217, paragraphs 351, 352.

Preparing Crumbs for Fried Food.

Materials needed.—Stale bread, food chopper or rolling pin, and hardwood board, roasting pan or pie plates, oven, sieve.

Exercise.—Prepare the crumbs as described in Reference No. 34, p. 75.

Using Dry Crumbs for Homemade Cereal Food.

Materials needed.—Stale bread, stale cake, molasses, sugar and cream, saucers and spoons for serving, food chopper or rolling pin and hardwood board, baking sheets or roasting pan.

Exercise.—Prepare homemade cereal breakfast food as described in Reference No. 26, p. 31, using bread and cake and starting the drying of bread dipped in molasses and water.

Raised Doughnuts.

Materials needed.—Sponge previously set, flour, rolling pin, bread board, flour dredger, doughnut cutter, Scotch frying bowl, 3 pounds of fat for frying, unglazed paper, mixing bowl, wooden spoon.

Exercise.—Make the doughnuts according to the directions given in Reference No. 33, p. 82.

Doughnuts with Baking Powder.

Materials needed.—Flour, salt, baking powder, eggs, milk, butter, sugar, powdered cinnamon, nutmeg and grater, rolling pin, bread board, flour dredger, doughnut cutter, mixing bowl, wooden spoon, knife, teaspoon, tablespoon, measuring cup.

Exercise.—Make doughnuts No. 1 by the recipe given in Reference No. 33, p. 81.

Rice Croquettes.

Materials needed.—Rice, milk, salt, eggs, butter, crumbs for covering fried food, bowl of fat for frying, unglazed paper, wire spoon.

Exercise.—Make rice croquettes, using the directions given in Reference No. 34, p. 281.

FIFTEENTH LECTURE—DOUGH RAISED WITH EGGS. ICING FOR CAKE.

In some cases dough is raised in part or wholly by means of air beaten into eggs, the egg albumin forming bubbles filled with air. When in the oven the cold air expands, making the mixture porous and light. Cake is an example of this. Cakes are of two general kinds—(1) sponge cakes and (2) butter cakes.

SPONGE CAKES.

These cakes never have butter in them and are frequently raised entirely by means of eggs. The eggs usually provide also the only moisture used, but from motives of economy, when eggs are expensive, water is sometimes added and baking powder used.

Sponge cakes are mixed differently from butter cakes and should be baked in a cooler oven and about one and one-fourth times as long. The tests and rules for baking are the same for sponge cakes and butter cakes.

BUTTER CAKES.

The effect on dough of shortening is to make it tender and brittle instead of tough and elastic. Fats differ in their shortening power (Reference No. 16, p. 347, paragraph 5), but butter is generally used in cake on account of its flavor.

In gingerbread and other highly spiced cakes pure rendered beef or veal fat may be substituted for butter, as the flavor of the fat will not be so evident as in other kinds of cake.

COOKIES.

Any butter cake recipe can be used for cookies if only one-third to one-half the amount of milk called for is used. Roll the dough out on a floured board. Cookies should bake in a slow oven for eight to ten minutes.

GENERAL RULES FOR MAKING CAKE.

Materials Used.

Pastry flour will make lighter and more tender cake than standard flour. If standard flour is used take two tablespoonfuls less for each cupful measured. Fine granulated or powdered sugar should be used. Brown sugar may be used for dark fruit cake. Much variety can be made in cakes by introducing fruit, nuts, spices, different flavoring extracts, or chocolate into the dough, and for white cakes using only the whites of the eggs, or for yellow cakes a larger number of yolks than whites. The materials should all be good of their kind.

Preparing the Pans.

Grease them well with butter or lard, or line them with buttered or paraffin paper. Bright, new pans will not need to be buttered for sponge cakes and if left unbuttered a more delicate crust is formed.

Mixing.

This is done differently in sponge cakes and butter cakes. (References No. 34, p. 372; No. 33, p. 413.)

Baking.

If a wood or coal fire is used have a small or moderate-size fire, but one which will last without much addition through the baking. Regulate the oven long enough before the cake is to go in to have the dampers adjusted, as they are to remain throughout the baking. If this is not done the dampers must be changed to regulate the heat during the baking, and the cake will not be so well baked. For the time of baking different cakes and the tests for baking see References No. 34, p. 370; No. 51, p. 119.

Removing from the Pans.

Most cakes can be at once removed from the pan when baked, but very rich cakes and dark fruit cake will be liable to break unless first allowed to stand about five minutes. (References No. 34, pp. 369–373; No. 33, pp. 412–416.)

FROSTINGS OR ICINGS AND FILLINGS.

Frostings or icings may be made (1) of a sirup made from granulated sugar and water poured, boiling hot, on beaten whites of eggs; or (2) by adding raw confectioners' or pulverized sugar to beaten whites or yolks of eggs; or (3) by pouring boiling hot water or milk over finely pulverized sugar.

When icing is made by the second method some cooks beat the egg white until very stiff, others beat it only a very little. If the egg is slightly beaten the icing has a different texture and remains soft longer.

Icings should be soft enough to spread evenly, but not so soft as to run off the cake. A good test for this is to make a cut into the frosting in the bowl with a knife. If the cut just disappears in one minute the frosting is the right consistency. If the cut closes sooner the frosting is too soft; if not smoothed together in one minute, it is too stiff. If frosting is put on the cake a little too stiff, so that it is rough when spread, smooth it with a few strokes of a knife dipped into boiling water.

In frosting a cake the loaf is usually turned upside down and the bottom and sides are covered. This seals the pores and makes the cake keep moist longer. If only one surface is to be covered ice the top.

A great variety of frostings can be made from the three fundamental frostings by adding different flavorings or coloring matter. (References No. 34, pp. 384, 385; No. 33, pp. 429, 440.)

EXPERIMENT AND PRACTICE WORK, FIFTEENTH LECTURE.

Sponge Cakes.

Materials needed.—Eggs, sugar, lemon, flour, salt, mixing bowls, egg beaters, small bowls or plates to beat eggs on, wooden spoons, measuring cups, teaspoons, tablespoons, knives, small bread pans, cream of tartar, vanilla, cake coolers, 1 angel cake pan.

Exercise.—Each student make a sponge cake using the directions given in Reference No. 37, p. 70. One student may substitute a white sponge cake (angel cake) using whites of 12 eggs, 1½ cupfuls of sugar, 1½ teaspoonfuls cream of tartar, 1 teaspoonful of vanilla, and 1 cupful and 1 tablespoonful of flour. Mix it in the order the ingredients are given, using an egg whisk to mix with. The eggs should be beaten until nearly but not quite stiff. Bake it in an unbuttered pan or one lined with unbuttered paper for 55 minutes, keeping a pan of boiling water in the oven under the cake during the first 45 minutes. When done, if no paper is used in the cake pan, turn the pan upside down on a cake cooler or wire rack until the cake is cold.

One student may make a sponge cake using fewer eggs and adding water and baking powder for comparison. (Reference No. 33, p. 416.)

Butter Cakes.

Materials needed.—Flour, butter, sugar, eggs, vanilla, chocolate, milk, nuts, raisins, currants, citron, almond extract, nutmeg, an oven, small bread pans, mixing bowls, measuring cups, teaspoons, table-spoons, knives, wooden spoons, egg beaters, saucepans for melting the cholocate over water.

Exercise.—Each student make a butter cake, using the rule for either " plain cake " or " cream almond cake." (Reference No. 37, p. 69.) The plain cake, which is the same recipe as " cup cake," may be varied by several students, one adding chocolate to the dough, one flavoring with vanilla, one with nutmeg, one adding dried fruit, one baking the cake in two thin layers and putting filling between them and on top, and one making marble cake with a little white and chocolate dough.

Frostings.

Materials needed.—Eggs, granulated sugar, confectioners' sugar, milk, water, chocolate, 1 lemon, vanilla extract, almond extract, 1 orange, cochineal or some commercial vegetable color of good quality, small bowls, saucepans, wooden spoons, knives, teaspoons, table-spoons, measuring cups, custard cups.

Exercise.—Each student make a different frosting, using the rule given in Reference No. 37, p. 73, or one-third of the recipe for ornamental frosting (Reference No. 34, p. 384). Make orange frosting (Reference No. 34, p. 385), and milk and water frostings, boiled frosting, chocolate frosting, and pink frosting.

APPENDIX.

REFERENCES.

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39. Enzyms and Their Applications, Chap. XIV. Panary Fermentation, by J. Effront and S. C. Prescott. New York, 1902.

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LIST OF APPARATUS AND MATERIALS NEEDED.

[Prices are retail catalogue prices, subject to some discount.]

9 chairs	$9.00
3 or 5 [a] kitchen tables, at $1.25 each	3.75
1 or 8 [a] smokeless burners	.25
1 refrigerator if the course is given in a warm season	10.00
1 kitchen cupboard	13.00
1 stove with 1 or 2 [a] ovens	20.00
Red rubber tubing to fit gas-burners, per foot	.15
1 wire broiler	.70
2 or 4 [a] bread boards	.80
4 bread pans	.40
1 bread box	.75
2 2-quart baking dishes	.50
8 [a] small bread pans 5 inches long by 2½ inches wide by 2 inches high	1.16
2 frames for cooling bread or cake	.50
2 or 8 [a] measuring cups, graduated in thirds and quarters	.20
1 can opener	.05
1 cake turner	.10
1 fine colander	.20
2 2-quart agate double boilers	3.00
2 1-quart agate double boilers	1.80
2 doughnut cutters	.20
2 biscuit cutters	.20
1 or 4 [a] agate dish pans	.75
1 Dover egg beater	.20
1 or 4 [a] flour dredges	.10
1 or 4 [a] egg whisks	.02
1 food chopper	1.50
2 or 8 [a] steel forks	.20
1 garbage kettle	1.00
1 or 4 [a] graters	.10
1 set gem pans	.30
1 griddle	.45
1 bread knife	.50
1 butcher knife	.50
2 or 8 [a] case knives	.20
1 iron lemon squeezer	.75
1 lid lifter (if a range with lids be used)	$0.05
1 flour sieve	.20
1 towel roller	.25
1 "Turks head" pan	.25
6 or 16 [a] tin teaspoons	.25
3 or 8 [a] tin tablespoons	.24
1 agate teakettle	1.50
1 wire spoon	.05
1 2-quart covered agate saucepan	.50
8 [a] 1-pint agate saucepans	1.20
3 or 8 [a] soap dishes	.60
1 silver butter knife	1.00
3 silver tablespoons	2.00
12 silver knives	5.00
12 silver forks	5.00
12 silver teaspoons	4.50
3 vegetable dishes for serving food	1.00
12 china plates for serving food	2.00
12 china saucers for serving food	1.20
1 dozen thin glass tumblers	.50
1 sugar bowl	.50
1 cream pitcher	.50
2 or 8 [a] kitchen plates	.20
2 or 8 [a] 1-quart white bowls	.20
2 or 8 [a] custard cups	.10
4 large mixing bowls	2.00
9 yards dish toweling (fine)	1.62
10 yards dish toweling (coarse)	1.50
2 yards heavy crash (narrow)	.24
2 yards heavy crash (one-half yard wide)	.36
18 damask napkins	4.50
1 yard cheese cloth	.05
12 yards roller toweling	2.64
1 soft broom	1.00
1 dustpan	.25
1 soft brush	.25
1 fiber pail	.40

[a] The larger number will be needed if each student performs every exercise.

1 hand basin	$0.30
1 porcelain evaporating dish, capacity 80 cubic centimeters	.20
1 one-half pint glass beaker	.40
1 30-mesh sieve	.25
Copper gauze 6 by 6 inches	.08
1 dozen test tubes	.15
1 flask, capacity 500 cubic centimeters	.22
1 rubber stopper to fit flask	.15
1 compound microscope, one-eighth inch objective	30.00
1 magnifying glass	1.00
1 dozen microscope slides	.10
1 dozen cover slips	.10
2 inoculating needles	.05
1 10-cubic centimeter measuring glass	.25
1 small mortar and pestle	.65
1 package 6-inch filter paper	.25
1 glass funnel, diameter 145 millimeters	.16
18 inches glass tube	.20
1 glass rod	.01
1 test tube holder	.15
1 confectioners' thermometer, graduated to 500° F	3.00
1 oven thermometer, graduated to 400° F	3.00
1 ounce hydrochloric acid	.10
1 ounce concentrated nitric acid	.10
1 ounce tincture iodin	.10
½ ounce amylopsin	.25
½ ounce pepsin	.25
½ ounce pancreatin	.25
1 pint lime water	.01
2 ounces Fehling's solution	.40
½ ounce acid phosphate of lime	.03
½ ounce ammonia alum	.05
1 packing box at least 18 inches by 18 inches by 18 inches	.10
18 inches No. 20 copper wire	.01
1 box small gummed labels	.10
8 pencils	.08
8 notebooks	.80
1 pair large scissors	.75
1 ounce rock candy	.01
1 ounce hops	.05
½ ounce cochineal or substitute	.20
1 ounce glucose	.01
½ ounce precipitated chalk	.02
Cotton batting	$0.01
1 pound hominy grits	.06
1 pound coarse hominy	.08
1 pound rolled oats	.05
2 pounds rice	.16
3 pounds corn meal	.08
2 pounds buckwheat flour	.12
2 pounds rye flour	.05
1 pound graham flour	.05
½ pound gluten flour	.05
1 pound entire-wheat flour	.10
12½ pounds straight flour	.50
5 pounds lard	.75
1 lemon	.02
1 pint molasses	.06
13½ quarts whole milk, at 7 cents a quart	.95
1 pint skimmed milk	.02
1 quart cream	.25
1 pound macaroni	.15
1 orange	.03
10 potatoes	.05
½ pound dried peas	.035
½ pound dried beans	.03
1 pint peanuts	.05
5 pounds granulated sugar	.28
3 pounds confectioners sugar	.24
1 cabbage	.05
1 pound unsweetened chocolate	.40
½ pound cheese	.10
½ ounce powdered cinnamon	.05
1 pound dried currants	.12
½ pound raisins	.06
¼ pound citron	.05
¼ pound candied orange peel	.05
¼ pound cream of tartar	.15
3 dozen eggs, at 25 cents	.75
1 fowl	.60
1 pound fish	.13
2 pounds beef	.32
1 shin bone of beef	.10
1 soup bone	.10
2 ribs mutton	.10
½ pound suet	.05
4½ pounds butter	1.35
1 loaf stale bread	.03
1 green banana	.02
1 apple	.01
1 bay leaf	.01
1 bottle almond extract	.25
2 ounces vanilla extract	.25
¼ pound each of four brands of baking powder	.50

$\frac{1}{2}$ pound standard brand of baking powder	$0.25
1 pound rock salt	.01
1 pound cornstarch	.10
1 sack of salt	.05
$\frac{1}{4}$ pound pepper	.10
1 ounce tapioca	.02
1 can tomatoes or its equivalent in fresh tomatoes	.12
1 pint vinegar	.03
$\frac{1}{4}$ pound salt mackerel	.05
1 pound granular wheat breakfast food	$0.075
24 cakes compressed yeast	.48
1 package dry yeast	.05
4 cakes brown soap	.20
1 cake sand soap or similar material	.10
2 cakes castile soap or other white soap	.20
1 pound washing soda	.02

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